TEMS™ CellPlanner

WCDMA Technical Reference Manual

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Contents

Preface i

1 Overview of TEMS CellPlanner 1-1

About TEMS CellPlanner 1-2
Installation 1-2
Product Packaging 1-2
Licenses 1-3
Support and FAQ 1-4

2 Concepts of WCDMA Algorithms 2-1

TEMS CellPlanner for WCDMA 2-2
Services and WCDMA Bearers 2-4
Receiver Sensitivity 2-5
Transmitter Output Power 2-6
Traffic Modeling in TEMS CellPlanner 2-7
Types of Losses 2-14
Handling Traffic Demand Mixes 2-16
Concept of Air-Interface Speech Equivalents (ASE) 2-24
Concept of Channel Elements 2-25
Simulating Admission and Congestion Control 2-30
Handling Log-Normal Fading Margins 2-34
Pathloss Fading Tables 2-39
Handling Soft and Softer Handover 2-41
Principles for Optimizing Scrambling Codes 2-44
Principles of Pilot Power Optimization 2-49
Area Configurations in WCDMA Networks 2-51

3 Using HSPA in WCDMA Networks 3-1

Introduction to HSPA 3-2
Terminology of HSPA 3-4
Channel Structure of HSDPA 3-5
HSPA Features 3-6
HSPA Terminals 3-10
HSPA Planning Methodology 3-12
How to Integrate HSPA in a WCDMA Network Plan 3-15

4 Using MBMS in WCDMA Networks 4-1

About MBMS 4-2
MBMS System Architecture 4-2
MBMS Area Concepts 4-3
MBMS Radio Channels 4-3
Soft Combining with MBMS 4-3
MBMS on a Specific Frequency 4-4
MBMS Planning Aspects 4-5

5 WCDMA Algorithms 5-1

Coverage and Capacity Simulations 5-2
Impact of Parameter Settings on WCDMA Analysis 5-10
Non-iterative Analysis 5-18
Neighbor List Analysis 5-18
Scrambling Code Planning 5-20
Pilot Channel Power Balancing 5-22
Automatic Cell Planning 5-26

Index I-1

Preface

Document Conventions

This document uses the following conventions:

Bold type	Window names, button names, and keyboard keys are displayed as bold text. Example: Click **Edit.**
Menu↗Selection	Navigation in menu paths are displayed as bold text with arrows between menu levels.
`Typewriter type`	File names and literal input and output. Example: `sites.xml`
Italic type	Book titles and definitions are displayed in italic. Examples: *carrier mapping, Technical Reference Manual*
Left-click Right-click	All instructions including mouse clicks assume a mouse configured with the left mouse button as primary button.

Navigation

Use the ALT ← and ALT → buttons to navigate between link jumps in the Manuals.

Assumed Knowledge

This documentation presumes that you have good knowledge about radio network planning principles and the radio technology to plan.

Disclaimer

The parameter values in this manual are just examples to help you getting started quickly, and do not constitute any performance guarantees for the planned equipment of your final network planning.

Proper parameter values depend on the equipment version, the operator's business plan, and the operator's network deployment strategy. Recommended parameter values should be provided by the operator, the equipment vendor or your service delivery organization.

Manuals

The following PDF manuals are delivered with the TEMS CellPlanner software:

Installation Guide
EN/LZT 108 9831 R4A

Describes system requirements, how to install and configure TEMS CellPlanner components and manage licenses, and provides an overview of all TEMS CellPlanner components. The procedures must be performed by a user with administrator privileges on the local computer. Some procedures require that you are an authorized TEMS CellPlanner administrator.

Common Features User's Guide
EN/LZT 108 9832 R4A

Includes Glossary of terms used in TEMS CellPlanner, concepts about licenses, and how use projects, explorer objects used by more than one radio technology, how to add sites and use site tools, filters, plots, neighbors, AMI, tuning propagation models, ASMT (Automatic Sector Model Tuning), puncturing, export and import data, and work with projects on server. Here TEMS CellPlanner administrators find how to administer users, groups and projects on servers shared by multiple users.

Common Features Technical Reference Manual
EN/LZT 108 9833 R4A

Describes radio technology independent algorithms, parameters and file formats.

GeoData User's Guide
EN/LZT 108 9834 R4A

Describes geodata concepts, supported geodata formats, conversion between different map formats, how to use map data tools in TEMS CellPlanner. The chapters about providing and importing map data are intended for administrators of map data. Other chapters are intended for users of map data.

Map Import Wizard User's Guide
EN/LZT 108 9943 R2A

Describes how to import map data using a generic wizard similar to the one provided with TEMS LinkPlanner. The intended reader is administrator of map data.

LTE User's Guide
EN/LZT 108 9944 R3A

Describes how to use LTE functions of TEMS CellPlanner, including analysis, and creation of plots and reports.

LTE Technical Reference Manual
EN/LZT 138 0235 R2A

Describes LTE network planning principles, analysis details for advanced users, and cell ID planning principles.

WCDMA User's Guide
EN/LZT 108 9837 R4A

How to use WCDMA functions of TEMS CellPlanner, including analysis, and creation of plots and reports.

WCDMA Technical Reference Manual
EN/LZT 108 9838 R4A

Describes concepts and overviews of WCDMA algorithms, and HSPA and MBMS in TEMS CellPlanner.

GSM User's Guide
EN/LZT 108 9835 R4A

Describes how to use the GSM functions of TEMS CellPlanner, including analysis, and creation of plots and reports.

GSM Technical Reference Manual
EN/LZT 108 9836 R4A

Describes overlaid/underlaid cell structures, reuse patterns, manual frequency planning, automatic frequency planning (AFP), automatic hopping frequency set (HFS) planning, optimization of BSIC, HSN and MAIO, fractional load planning, and effective subscriber modeling. Also describes the GSM algorithms and file formats used in TEMS CellPlanner.

WiMAX User's Guide
EN/LZT 108 9839 R4A

Describes how to use the WiMAX functions of TEMS CellPlanner, including analysis, and creation of plots and reports.

1
Overview of TEMS CellPlanner

This chapter provides an overview of the TEMS CellPlanner product.

Topics **Page**

About TEMS CellPlanner 1-2
Installation 1-2
Product Packaging 1-2
Licenses 1-3
Support and FAQ 1-4

About TEMS CellPlanner

TEMS™ CellPlanner is a graphical PC-based application for designing, implementing, and optimizing mobile radio networks. It assists you in performing complex tasks, including network dimensioning, traffic planning, site configuration, frequency planning, and network optimization.

Installation

The Installation Guide describes how to install software and licenses.

Product Packaging

The product package includes the software components listed below.

What is actually installed depends on your selection in the installation wizard.

Product Components	Selecting this component installs...
• TEMS CellPlanner *named "TEMS CellPlanner Client" in the manuals*	• Radio Technology Features • Planning Features • Manuals • Map tools, geodata conversion software, demo maps, filters, scripts • Citrix software - relevant only if you are going to offer this TEMS CellPlanner installation as a Citrix service
• Enterprise Server	Enterprise Server software plus the User Administration software
• Zero Admin Server	Zero Admin Server software plus the User Administration software
• User Administration	User Administration software only
• License Server	License Server software only

Some of the components are licensed, see Licensed Components on page 1-3.

The Installation Guide provides an overview of each component and how the components relate to each other.

Licenses

The Installation Guide describes how to install licenses.
The Common Features User's Guide describes how to activate licensed features.

Licensed Components

Three of the Product Components are licensed:

TEMS CellPlanner *named "TEMS CellPlanner Client" in the manuals*	To start TEMS CellPlanner you need a license for at least one of the Radio Technology Features. Additional licenses are required for each of the Radio Technology Features and Planning Features to use.
Enterprise Server	License required to start the server
Zero Admin Server	License required to start the server

Radio Technology Features

Each of the radio technology software modules listed below require an installed and activated license. How to use the radio technology software is described in adherent user guides and technical reference manuals.

- GSM
- WCDMA
- WCDMA,HSPA
- WiMAX
- LTE

Planning Features

Additional planning features can be used together with the radio technology software. These additional software modules require a license for the feature itself and a license for the adherent radio technology:

• Automatic Cell Planning	Requires WCDMA or WCDMA,HSPA license
• Automatic Frequency Planning	Requires GSM license. This license is required also for automatic HFS planning.
• Automatic Measurement Integration and ASMT	Requires license for at least one of the Radio Technology Features ASMT = Automatic Sector Model Tuning.

Support and FAQ

For support and FAQ about TEMS CellPlanner, use the TEMS support web site:

www.ascom.com/networktesting

To provide TEMS support with information when reporting a problem, follow the instructions in chapter *Support Information* in the Installation Guide.

2
Concepts of WCDMA Algorithms

This chapter describes the general concepts used for WCDMA analysis processes of TEMS CellPlanner.

Topics **Page**

TEMS CellPlanner for WCDMA 2-2
Services and WCDMA Bearers 2-4
Receiver Sensitivity 2-5
Transmitter Output Power 2-6
Traffic Modeling in TEMS CellPlanner 2-7
Types of Losses 2-14
Handling Traffic Demand Mixes 2-16
Concept of Air-Interface Speech Equivalents (ASE) 2-24
Concept of Channel Elements 2-25
Simulating Admission and Congestion Control 2-30
Handling Log-Normal Fading Margins 2-34
Pathloss Fading Tables 2-39
Handling Soft and Softer Handover 2-41
Principles for Optimizing Scrambling Codes 2-44
Principles of Pilot Power Optimization 2-49
Area Configurations in WCDMA Networks 2-51

2.1 TEMS CellPlanner for WCDMA

TEMS CellPlanner provides advanced and accurate WCDMA analysis with flexible parameter settings to support different planning methods, with or without Monte Carlo simulations.

WCDMA network planning functions allow you to use the application from network design through network deployment and optimization. Depending on the design stage and level of detail of a network plan, you can select different levels of calculation speed and accuracy for the predictions and simulations.

Interdependencies between coverage, capacity, and service quality in a WCDMA network require a sophisticated Monte Carlo simulator. TEMS CellPlanner has the most advanced Monte Carlo simulator available in commercial network planning applications today.

You may perceive Monte Carlo simulations as time consuming, especially when a network plan is in an early state. In such cases, the main focus is to get a quick estimate on network coverage and capacity rather than a detailed simulation of the network performance. In TEMS CellPlanner, Monte Carlo analysis is designed to be more flexible and convenient to use.

Monte Carlo analysis provides detailed statistics output on network, site, cell, and user level. It includes detailed information on the handover status of the network plan.

2.1.1 Soft/Softer Handover

Soft and softer handover analysis is a major consideration for WCDMA network design. Depending on the actual network plan, an optimum level exists for soft and softer handover in WCDMA to yield a high WCDMA radio performance without degrading the air interface capacity of the system.

All handover situations are identified in graphical plots as well as in cell-by-cell statistical results.

2.1.2 Area Planning for Location, Routing and Service Areas

Location area (LA), routing area (RA), and service area (SA) information is required by the UMTS network to keep updated location and paging information for all terminals over the entire network coverage area.

Using TEMS CellPlanner, you can assign location area, routing area, and service area related information on a per-cell level. Area configuration information can be viewed and printed in plots for particular cells or the entire network.

2.1.3 Support for Planning Mobile Positioning Data

TEMS CellPlanner supports planning best server coverage polygons for positioning services support in UTRAN. You can generate and store positioning information on a per-cell level.

2.1.4 Co-Planning and Neighbor Planning for 2G and 3G Networks

From site and antenna system re-use to a detailed neighbor planning module, TEMS CellPlanner facilitates co-planning of 2G and 3G networks. You can share network data between the two systems and provide detailed planning for Inter-system handover planning and analysis.

By combining all major radio technologies into one data model on the same software platform, TEMS CellPlanner allows you to efficiently run co-planning for 2G and 3G networks without needing to switch the mode of operation for the application.

2.2 Services and WCDMA Bearers

A service is some type of end-user application, available in the subscribers' mobile phone or communication device.

Examples of such services include:

- Voice communication
- E-mail
- Web-surfing
- Video conferencing
- Video streaming

Services require different channel bit rates and delay properties, so the system must provide specific bearers to meet all the requirements of end-user services.

You must make an estimate of service types and traffic demand, considering that the WCDMA system provides limited WCDMA bearers: channels with certain Quality of Service properties in the WCDMA air interface.

2.2.1 Mapping End-User Services to WCDMA Bearers

Once you identify WCDMA bearers, you must map the traffic demand from the end-user services onto the WCDMA bearers, and identify the specific traffic demand expected for the selected bearers. Traffic demand for the different WCDMA bearers is input to WCDMA analysis as the number of simultaneous users per square kilometer for each WCDMA bearer.

The following table provides examples of mapping end-user services to WCDMA bearers:

WCDMA Bearer	End-User Service/Application
12.2 kbps AMR speech bearer	Speech services
64 kbps conversational data bearer	Video conferencing and video streaming, multimedia calls
128 kbps interactive data bearer	WWW-access, Corporate LAN access, Image transfer (MMS)
128 kbps background data bearer	Machine-machine communication, e-commerce, e-mail

2.3 Receiver Sensitivity

Receiver sensitivity of both mobile terminals and base stations is of great concern in network planning. The higher the receiver sensitivity the better coverage and capacity can be achieved in a WCDMA network.

2.3.1 Receiver Sensitivity Dependencies

Receiver sensitivity depends on several factors:

- Eb/Io requirement for the WCDMA bearer
- Mobile terminal speed and radio propagation environment
- Air interface and bearer data rates
- QoS requirements for the bearers
- Noise values of the receivers, and use of pre-amplifiers for base stations (tower-mounted amplifiers, tower top amplifiers)

You can obtain detailed values of receiver sensitivity for base stations and mobile terminals from the equipment manufacturers.

2.3.2 Typical Values Versus Guaranteed Values

When planning for WCDMA coverage and capacity using TEMS CellPlanner, you should use typical values, rather than guaranteed values, for receiver sensitivity. When using guaranteed values the *guarantee margin* applied by the manufacturers on top of the typically measured sensitivity values leads to a rather pessimistic design.

WCDMA networks are still in the initial stages of deployment and most receiver sensitivity values available today for network planning purposes are derived from system simulations. You should replace these values with actual measured sensitivity values from real networks once they are available.

2.4 Transmitter Output Power

Power is the common shared resource in WCDMA network coverage. The capacity of individual cells depends on the available output power of both the base stations and the mobile terminals.

2.4.1 Mobile Terminal Transmitter Output Power

Mobile terminal output power is an important parameter for UL coverage planning in a noise limited WCDMA network.

The 3GPP TS 25.101 specifies different power classes for mobile terminals. Most terminal manufacturers have applied power classes 3 (+24 dBm) and 4 (+21 dBm) to their terminals. Mobile terminals may also be able to switch output power class depending on the WCDMA bearer(s) set up in the channel.

Detailed values on mobile terminal output power to be applied for network planning have to be obtained from the respective equipment manufacturer. Typical output power values should be used rather than guaranteed values to provide a more realistic design of the WCDMA network.

2.4.2 Base Station Transmitter Output Power

In TS 25.104 3GPP has not applied any transmit power classification for base stations as it was done for the mobile terminals. Consequently there is a large variety of different maximum output power values available from different network equipment manufacturers.

The maximum output power of a base station depends on the intended use of that base station. Base stations used for macro-cell large area coverage usually have a much higher transmitter output power than mini-cell base stations for limited coverage in high capacity areas.

It is important to clearly identify the types of base stations to be used in the network planning process and the power requirements that need to be met by each individual base station type.

TEMS CellPlanner allows you to create base station templates (for example for macro-cells and for micro-cells) with individual parameter settings, easily re-used when placing base stations in the planned area of the network.

Detailed values on base station transmitter output power to be applied for network planning can be obtained from the respective equipment manufacturer.

Again, typical output power values should be used rather than guaranteed values to provide a more realistic design of the WCDMA network.

2.5 Traffic Modeling in TEMS CellPlanner

With the introduction of the third generation of mobile telecommunications, new and more advanced services are available to the end-users. Individual services require specific shares of the common radio resources in WCDMA. A need exists to specify different service classes in a way that allows network equipment and mobile phone manufacturers as well as service developers to apply corresponding requirements to their products.

2.5.1 Quality of Service Classes

3GPP has in TS23.107 standardized four different Quality of Service (QoS) classes available in the UMTS system to support various end-user applications. These classes comprise conversational, streaming, interactive and background types of services. The main parameters that characterize the different QoS classes are:

- Maximum bit rate and guaranteed bit rate
- Maximum packet or message size
- Residual bit error rate
- Transfer delay
- Priority

Services belonging to these QoS classes can be defined in the corresponding radio bearer properties.

2.5.2 Radio Bearer Types

The traffic modeling algorithms of TEMS CellPlanner consider two basic WCDMA radio bearer types. The first type are the circuit switched bearers. The second type of radio bearers are the packet switched type.

During iterative WCDMA analysis (Monte Carlo simulation), circuit switched bearers are tried for connection to cells before packet switched bearers.

When defining different QoS types for the radio bearers to be simulated in the WCDMA network, the traffic handling algorithms provide the following mapping to radio bearer types:

QoS Class	WCDMA Bearer Type
Conversational	Circuit switched
Streaming	Circuit switched
Interactive	Packet switched
Background	Packet switched

Conversational and Streaming QoS classes are considered as delay sensitive and high priority services, while the QoS classes Interactive and Background are treated as delay insensitive and lower priority services.

The QoS-to-bearer mapping has an influence on how the traffic handling is performed during connection set-up and for admission and congestion control in the simulations.

2.5.3 Handling Circuit Switched Bearers

Circuit switched WCDMA radio bearers are used to simulate provision of end-user services in QoS classes Conversational and Streaming. These services require a guaranteed bit rate from the radio network. Consequently, for coverage planning the peak bit rate of these services is used to arrive at a high confidence for the calculated coverage probability.

Speech Users

Users on circuit switched radio bearers do not use the *peak bit rate* available all the time. For instance, speech users have a certain voice activity of about 60%, implying that the peak rate of the channel is used for only about 60% of the total time for the conversation.

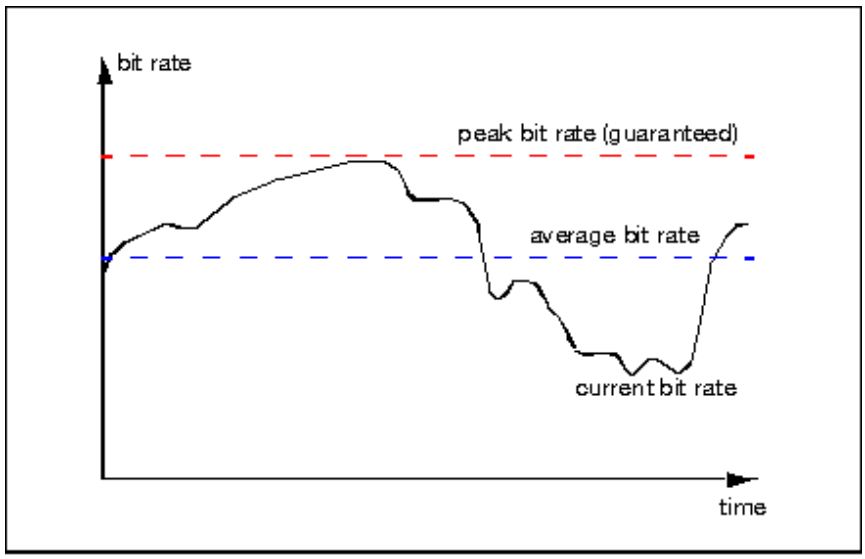
Video Streaming Connections

Another example are video streaming connections. The picture frame update rate and the required bit rate on the radio channel depend on the amount of movement in the video content to be transferred. Although the radio channel provides a certain guaranteed peak bit rate, it is used only for a specific percent of time during the ongoing connection. For the remaining time a lower bit rate, *current bit rate*, is sufficient to provide the expected quality of the video streaming service.

Therefore, a second bit rate - the *average bit rate* - is used to calculate the interference contribution and capacity requirements in the air interface for circuit switched bearers.

2.5.4 Illustration of Peak and Average Bit Rate Differences

The following illustration shows the difference between the peak and the average bit rates:



Peak and average bit rates are defined in the WCDMA bearer properties specifically for each rate set of the bearer.

2.5.5 Multiple Rate Sets

Depending on the application, a case may occur that a circuit switched service uses multiple rate sets, selected by the application control algorithms and depending on the load in the entire data network. To support such applications, multiple rate sets can be defined for circuit switched bearers.

Some applications require different rates on uplink and downlink along with the capability to independently switch bit rates on the two links. Independent bit rate switching is modeled by selection of symmetry properties of a radio bearer.

Multiple bit rate sets and symmetry properties are defined in the WCDMA bearer properties.

2.5.6 Handling Packet Switched Bearers

Packet switched applications have no stringent requirement for peak bit rate or for the overall delay over the data channel, as is the case for circuit switched applications.

For packet switched applications, a certain amount of delay and packet queuing is acceptable. Packet switched bearers can run on multiple rate sets, allowing

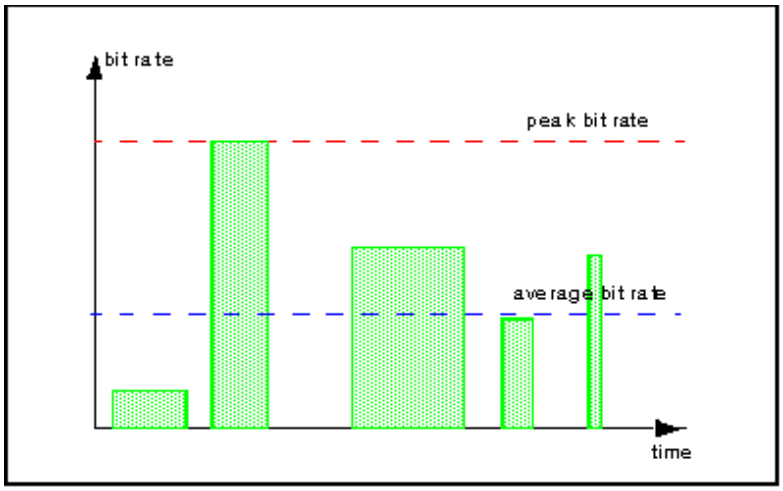
simulation of channel rate switching of a WCDMA radio network. Every time the air interface load does not allow for a high bit rate on a packet switched connection, the system tries to connect the users on a lower available rate set.

When spare capacity is available after all user connection attempts are satisfied, packet switched users down-switched in their bit rate are retried for connection on a higher bit rate. Users on packet switched connections may be active or inactive at any given point, independently on uplink or downlink. The traffic modeling algorithms of TEMS CellPlanner simulate this behavior when the symmetry of the radio bearer is switched off.

The WCDMA bearer properties allow you to define different rate sets for a packet switched bearer. User activity or inactivity is simulated by the assignment of a calculated activity factor to the generated users in the network for each trial. The user activity factor is calculated from the ratio between the maximum and the average bit rate for a particular rate set of the WCDMA bearer. The user activity can be defined differently for the different rate sets of a packet switched radio bearer.

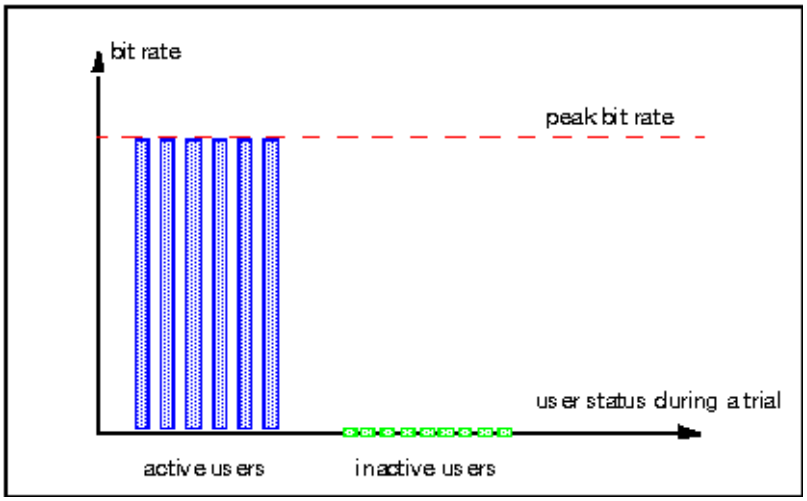
2.5.7 Packet Switched Variations

The following illustration shows variable packet sizes, bit rates and inactive periods for a packet switched connection. Like simulation for traffic modeling, packet switched users are considered as active or inactive.

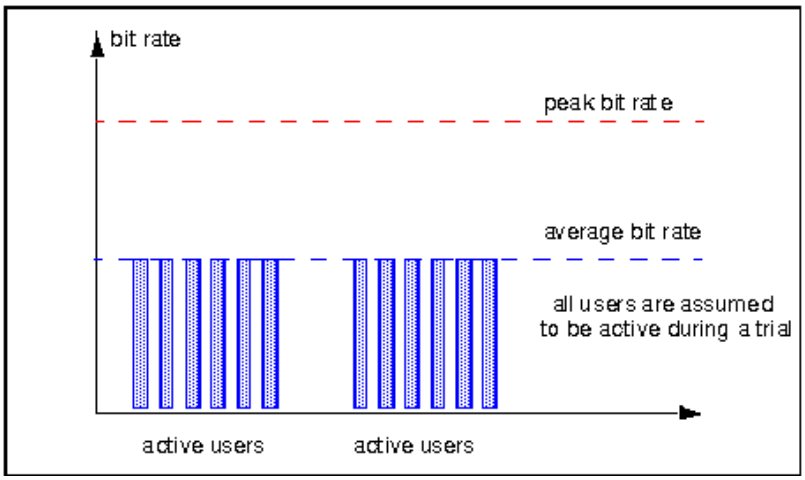


If the user is active he is assumed to transmit on the peak bit rate. When the user is inactive, the bit rate is set to zero. This mode is applied when the bearer is

simulated in the **peak power mode**. An example of handling user activity in peak power mode is illustrated in the following figure.



When the packet switched WCDMA bearer is run in **average power mode**, it is assumed that all generated users are active, but they use only air interface resources corresponding to the average bit rate specified in the bearer properties. An example of handling user activity in average power mode is illustrated in the following figure.



Compared to the power consumed by a bearer in peak power mode, the power for connecting the bearer in average power mode is scaled down by the activity factor.

2.5.8 Comparing Peak Power Mode and Average Power Mode

Since the downlink power required by each terminal is scaled down by the activity factor in the average power mode of the bearer, the available downlink power in the cell can be shared between a higher number of circuit switched and packet

switched bearers than in the peak power mode. The uplink noise rise caused by each connected bearer is also scaled down by the activity factor in average power mode, so a higher number of bearers can be connected in a cell before the (user defined) noise rise limit is reached.

The advantage of peak power mode is a fairly exact model of the traffic load and resource use at a specific moment. A possible disadvantage of peak power mode is that an active terminal using a high bit rate and high power might block other active terminals from being connected, although in real life these bearers would be connected but forced into inactive state by queuing their transmission. These connections would become active as soon as the required resources become available.

In average power mode it is possible to connect more bearers to a cell as long as the sum of their average power requirements does not exceed the total power limit. This better model of queuing does not model the real fluctuations of the power used by active bearers. As a result, the downlink and uplink interference become more averaged out than in real life.

2.5.9 Simulation Settings

Although TEMS CellPlanner allows for flexible assignment of power modes to packet switched and circuit switched radio bearers, it is suggested starting a network simulation with the following power mode settings:

QoS Class	WCDMA Bearer Type	Power Mode
Conversational	Circuit switched	average power mode
Streaming	Circuit switched	average power mode
Interactive	Packet switched	peak power mode
Background	Packet switched	peak power mode

2.5.10 Impact of CS and PS Bearer Type on Traffic Demand Definition

Traffic demand is defined in TEMS CellPlanner as the simultaneous number of users per square kilometer using a specific WCDMA bearer for the connection. Traffic demand can be treated as a specific density of active terminals over a specific area. Traffic demand may be based on a landuse-dependent traffic density map, or based on an uniform distribution of users in the network.

For the circuit switched bearer, all terminals defined in the traffic demand (and admitted to the system) are seen as being active. The traffic handling algorithms in TEMS CellPlanner calculate the resource utilization in terms of ASE for all active bearers.

For the packet switched bearer, TEMS CellPlanner randomly sets some attempted bearer connections based on the calculated activity factor to inactive state. To correctly compute the resource utilization in terms of ASE it is important to define the traffic demand for such bearers correctly. A user connection on a packet

switched radio bearer does not consume any ASE resources when the radio bearer is in an inactive state.

Only those connections active at a certain point consume ASE resources and are included in the simulation. The traffic density value for a packet switched bearer does not include those connections assumed to be inactive. The traffic density for packet switched bearers can be calculated as (users per square kilometer):

$$D_{net} = D_{gross} * (p_{connect} / 100) * [t_{session} / (t_{session} + t_{idle})]$$

where:

D_{gross}	gross density of terminals using the bearer [terminals/km2]
$p_{connect}$	percentage of the terminals connected, or are trying to become connected, in a packet call at a given point of time [%]
t_{idle}	average idle time between packet sessions [s]

2.6 Types of Losses

In addition to propagation loss (pathloss), radio waves may suffer additional losses that need to be considered for network planning.

2.6.1 Building Penetration Loss

Building penetration loss is considered in TEMS CellPlanner as an additional uplink and downlink loss connected to certain terminal types.

In most GSM networks outdoor macro-cell base stations provide a large part of the coverage inside buildings. When applying the same approach to a WCDMA network, the radio waves suffer a strong additional attenuation when penetrating building walls and floors.

In such a case the building penetration loss must be considered. The loss depends mainly on the thickness of the walls and the construction materials (radio wave attenuation properties) used.

Typical values for building penetration losses are in the area of 12 to 24 dB. When planning for in-building coverage from outdoor base stations in WCDMA it is suggested that you measure the actual penetration loss rather than assuming a value for the overall network.

Since power is the common shared resource in the WCDMA radio interface, additional signal energy attenuations due to building penetration losses are compensated for by a drastic capacity decrease of the outdoor base station.

It is strongly suggested to consider dedicated in-building coverage solutions rather than planning for general in-building coverage from outdoor base stations.

The coverage confidence that can be achieved by predicting the pathloss based on radio propagation models is around 50%. Usually the requirements on coverage confidence as defined by the operator's business plans is much higher, in the order of 98% to 99,99%. Since long-term fading (log-normally distributed) is not taken into consideration by most radio propagation models a certain margin has to be applied on the required received signal. Such a margin is called *log-normal fading margin*.

TEMS CellPlanner includes the log-normal fading margins when calculating the required power on uplink and downlink for a user connection to the system. The fading margin applied does not depend on the bearer type or bit rate, since it is a margin added to the predicted bearer-independent pathloss.

2.6.2 Body Loss

Body loss is considered in TEMS CellPlanner as an additional uplink and downlink loss connected to certain terminal types.

When a mobile terminal is carried close to the body the radio waves suffer additional attenuation, since body tissue absorbs a part of the signal energy. It is assumed that speech users (including those with a portable hands-free equipment) carry their mobile terminals close to the body. An additional loss must be considered. A rough estimate of the body loss is 3 dB.

We can assume that data terminals, especially those with built-in screens, are held apart from the body, so body loss does not have to be applied to data terminals.

2.6.3 Car Penetration Loss

Car penetration loss is considered in TEMS CellPlanner as an additional uplink and downlink loss connected to certain terminal types.

For highway coverage planning, we assume that a large number of mobile subscribers use their terminals inside a car without an external antenna kit. In such cases, the radio waves must penetrate the body of the car, leading to an additional loss, as compared to terminals used just outside the car or with an external antenna kit.

A rough estimate of car penetration loss is 6 dB.

2.6.4 Do Not Use Both Body and Car Losses

When planning for mobile phone users holding the terminal close to the body while communicating inside a car without external antenna kit, body loss should not be applied, since this would lead to a rather pessimistic network design.

2.7 Handling Traffic Demand Mixes

In WCDMA networks power is the common shared resource both in the uplink and downlink directions. All WCDMA bearers provided by the system share power resources. Consequently, when simulating coverage and capacity of a WCDMA radio network by the use of advanced Monte Carlo simulations, all bearers must be considered simultaneously.

WCDMA analysis allows you to freely mix WCDMA bearers and traffic demand for coverage and capacity planning. You can assign traffic demand as:

- A uniform distribution over the whole planned area
- A land-use based traffic demand distribution
- A traffic density map

For WCDMA analysis all traffic densities of the different WCDMA bearers are combined into a traffic demand mix. The mix considers both the appropriate sharing of power resources and the interference contributions generated by all bearers at the same time.

2.7.1 Channel Models

An important parameter in WCDMA coverage and capacity planning is the quality requirement for a WCDMA bearer: bit energy over noise and interference E_b/I_o. This quality parameter depends on the radio environment and the speed of the mobile terminal.

The 3GPP specifications standardize the approach in network planning tools for modelling a channel to reflect the broadband channel properties of a WCDMA signal in a more realistic way than in previous channel models.

The following table provides an overview of some 3GPP-specified channel models applicable for WCDMA network planning:

Channel Model	Mobile Speed
Typical Urban (TU)	3 km/h
Rural Area (RA)	40 km/h
Hilly Terrain (HT)	120 km/h

2.7.2 Use of Channel Models

3GPP channel models are used in link level simulations to arrive at a signal quality in terms of bit energy over noise and interference (E_b/I_o required to support a certain bearer over the WCDMA air interface. Network equipment suppliers usually perform such simulations and provide detailed values on E_b/I_o for all bearers supported by their base stations.

E_b/I_o Values

The Eb/Io values depend on the speed of the mobile, the radio environment, the frequency band, the system release version, the service type, and the bit rate for the transmission. The Eb/Io requirement increases with increased mobile speed. For coverage planning a certain coverage probability (for example 99,98%) must be maintained within the service area of the network. The highest Eb/Io values should be applied in link budget calculations for coverage planning of a particular WCDMA bearer.

In most cases, terminal speed varies in a real network, and in network planning we cannot assume that all mobiles are moving at the same speed. Considering only the worst Eb/Io for a particular bearer for capacity planning would lead to a far too pessimistic network design. It is suggested that you apply a mix of different speeds of mobile terminals when doing capacity planning for WCDMA.

2.7.3 Mapping Channel Models to Radio Environment

The following example shows the three channel models mapped to the radio environment:

Area	TU, 3 km/h	TU, 40 km/h	RA, 3 km/h	RA, 40 km/h	RA, 120 km/h
Dense Urban / Urban	80%	20%	-	-	-
Suburban	60%	40%	-	-	-
Rural	-	-	35%	35%	30%

Detailed information on channel models and Eb/Io values to be used for network planning can be obtained from the network infrastructure supplier.

The air interface of a WCDMA radio network is designed to support high flexibility of radio bearer properties and channel bit rates. Different WCDMA radio bearers are supported at the same time, even when their QoS requirements and traffic demand patterns differ. WCDMA analysis functions must support a fully flexible mix of any bearers supported by UTRAN system equipment.

The air interface flexibility is supported by the concept of *traffic demand mix*, forming input to WCDMA analysis algorithms. In terms of traffic modelling, detailed information on the following parameters is required to run WCDMA analysis:

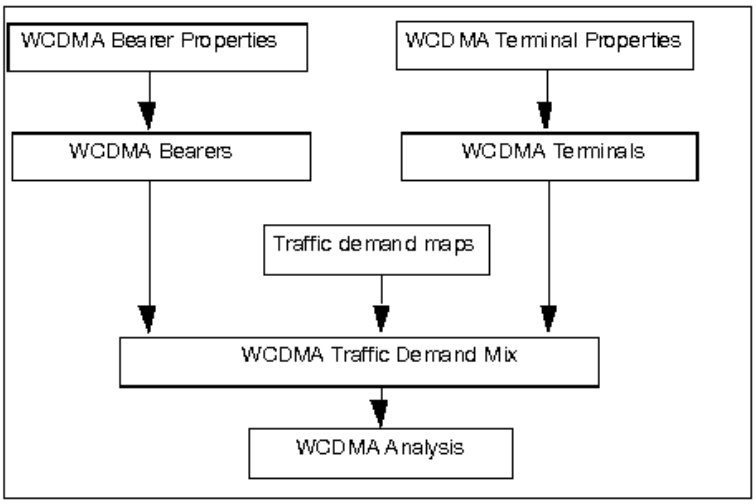
- WCDMA terminal properties
- WCDMA radio bearer properties
- Traffic density maps
- Traffic demand mixes for different WCDMA radio bearers

In multi-service networks, several services with differing parameters share the same radio resource. TEMS CellPlanner fully supports modeling multiple rate sets for all

packet and circuit switched WCDMA radio bearers. You can analyze voice, circuit switched data, and packet switched data simultaneously, and design for all WCDMA bearers offered in the UTRAN system.

2.7.4 Mapping Traffic Demand Mix

Mapping these parameters to the traffic demand mix is shown in the following figure:



2.7.5 WCDMA Radio Bearer Properties

Defining WCDMA bearer properties correctly is an important precondition for running WCDMA analysis to obtain accurate results.

The bearer parameters model the WCDMA radio bearers supported by the UTRAN network. TEMS CellPlanner models the radio bearers as physical channel resources provided by the UTRAN system rather than as end-user services.

For example, a video telephony service can theoretically be provided by bearers with different bit-rates and Quality of Service (QoS) requirements. For WCDMA analysis the radio bearers are clearly defined to provide video telephony service in the network. Mapping end-user services to the bearer is done in TEMS CellPlanner in the Description field of the WCDMA bearer.

2.7.6 General Bearer Properties

The general WCDMA bearer properties define how the bearer is to be treated in terms of connection priority at call establishment and in the case of a congestion situation in the simulated network.

The QoS class of the WCDMA bearer can be set to one of the 3GPP specified classes:

- Conversational
- Streaming
- Interactive
- Background

WCDMA bearers of type *Conversational* or *Streaming* are treated by WCDMA analysis as circuit switched radio bearers with high connection priority, whereas the WCDMA bearers of type *Interactive* or *Background* are treated as packet switched radio bearers with lower connection priority.

2.7.7 Connection Priorities of WCDMA Bearers

The *priority class* distinguishes the connection priority between different WCDMA bearers. The lower the priority number entered, the higher the connection priority of the bearer. When assigning priorities to different radio bearers you must ensure that a packet switched bearer is not given a higher priority than a circuit switched radio bearer. Circuit switched bearers should always be considered as higher priority than packet switched bearers. If the remaining air interface capacity is sufficient after the connection requirements for circuit switched radio bearers are satisfied, packet switched radio bearers should be allowed to try connection to the system.

When connecting users to cells, WCDMA analysis first connects users on circuit switched bearers. If enough air interface capacity remains, users on packet switched bearers are connected.

2.7.8 WCDMA Bearer Power Mode

The *power mode* for the bearer defines the way that user distribution is performed when running WCDMA analysis. In *average power mode* all users are assumed to be connected to the system simultaneously according to the specified traffic demand. Each WCDMA bearer in average power mode uses the average bit rate during the entire connection. Average power mode is suited for bearers that provide circuit switched radio connections in the UTRAN system.

For WCDMA bearers in *peak power mode* it is assumed that the user distribution considers a certain user activity factor when placing users out in the simulated network. The activity factor of the users is calculated for uplink and downlink connections separately and is based on the ratio between the maximum and the average bit rates set for the different links. In WCDMA analysis some of the users are active and transmit with the peak bit rate during that period. Other users are inactive. Although the bit rate during that period is set to zero, they consume hardware capacity resources (channel elements) in the RBS. WCDMA analysis simulates this behavior. Peak power mode is suited for bearers that provide packet switched radio connections in the UTRAN system.

The *Symmetry* option makes the radio bearer symmetrical in the radio connection. A bearer with symmetry switches uplink and downlink rates or connections simultaneously. If a fallback bit rate is defined for such a bearer the down- or up-switching of the bit rate is done simultaneously for uplink and downlink. Such properties are more common for circuit switched radio bearers QoS classes Conversational and Streaming).

In contrast, a packet switched radio bearer (QoS classes Interactive and Background) can switch the bit rate link-independent. The uplink and the downlink channels can be active at different times.

2.7.9 Rate Set Properties

The *rate set* properties of the WCDMA bearer define the RBS hardware and radio resource use if the WCDMA bearer is used for a particular user connection in the network.

Depending on the parameter values, the WCDMA bearer might consume larger resources in terms of channelization codes, ASE, or uplink and downlink power. Based on the load of the respective cells, WCDMA bearers with large resource consumption may be blocked by the simulated admission and congestion control for connection to certain cells. Detailed connection and blocking information is available in the statistic output file of WCDMA analysis.

The following WCDMA bearer parameters are considered by the simulated admission and congestion control algorithms of WCDMA analysis:

- Uplink peak bit rate requirements of the WCDMA bearer and the number of users connected on that bearer in the cell, resulting in a simulated uplink noise rise for the cells
- Downlink peak bit rate requirements of the WCDMA bearer and the number of users connected on that bearer in the cell, together with the power settings for common channels and the multipath fading environment result in a simulated downlink power (for the cell)
- ASE requirements for each radio bearer on uplink and downlink and the number of connected users simulated for the cell, resulting in a total requirement of ASE in the air interface
- Use of spreading factors 8, 16 and 32 for the high bit-rate WCDMA bearers, resulting in a certain occupation of the code tree capacity of the cells
- Use of all spreading factors in the cell, resulting in a certain occupation of the total available code tree resources for the cells.

2.7.10 WCDMA Terminal Properties

WCDMA analysis allows simultaneously modeling of several mobile terminals with different properties. The terminal properties are set in the Equipment explorer. The terminal parameters have the following meaning:

Sub-tab	Field	Description
General	Name	Your name for the terminal
	Antenna height	Average antenna height for the terminal; min. 0 m, max. 100 m, default 1.5 m
	GSM support	Indicates that the terminal supports GSM radio bearers. Enabling GSM support is mandatory for running GSM analysis functions for the terminal.
	WCDMA support	Indicates that the terminal supports WCDMA radio bearers. Enabling WCDMA support is mandatory for running WCDMA analysis functions for this terminal.
WCDMA	Gain (dBi)	The antenna gain of the terminal measured in dBi; min. 0 dBi, max. 100 dBi, default 0 dBi
	Rx loss (dB)	Additional downlink loss for the terminal in dB; min. 0 dB, max. 50 dB, default 3 dB. The sum of all losses applicable for the terminal is entered, such as body loss, car penetration loss and building penetration loss.
	Tx loss (dB)	Additional uplink loss for the terminal in dB; min. 0 dB, max. 50 dB, default 3 dB. This is the sum of all losses, and includes body loss, car penetration loss and building penetration loss.
	Max. output power (dBm)	Maximum transmitter output power of the terminal in dBm; min. 0 dBm, max. 40 dBm, default 24 dBm.
	Min. output power (dBm)	Minimum transmitter output power of the terminal in dBm; min. -90 dBm, max. 0 dBm, default -50 dBm.
	Noise figure (dB)	Noise figure of the terminal in dB; min. 0 dB, max. 40 dB, default 7 dB.
	Supported bearers	A list of previously defined WCDMA radio bearers supported by the terminal.

All terminals considered in WCDMA analysis must be defined in advance.

The terminal properties for WCDMA analysis should match as closely as possible the terminal properties expected in a real network. For example, most speed-centric terminals may be set to a maximum output power of +21 dBm, while data-centric terminals may allow for a maximum output power of +24 dBm. Such differences should be reflected when defining WCDMA terminals.

2.7.11 Traffic Density Definitions

Traffic density is a specific distribution of the traffic demand in an area of the network plan. You can plan the different WCDMA bearers with a traffic demand based on one of the following:

- An imported traffic density map
- A uniform distribution of users in the network
- A land-use based distribution of users
- A user-defined polygon with a certain traffic demand
- Multiple user-defined polygons with a certain traffic demand

Independent of the underlying map or polygon information, traffic demand input to WCDMA analysis is always expressed as the number of simultaneous users per square kilometer on a specific WCDMA bearer.

The definition of traffic density can be done without considering a particular radio bearer. First in the *traffic demand mix*, the connection is made between WCDMA bearers and specified traffic density maps. This approach allows a high degree of flexibility when defining bearers and traffic density maps.

For example, a certain distribution of subscribers within a planned area is captured by a general traffic density map. The map can be used as a base for defining all traffic demand values connected to the different WCDMA bearers by assigning one scaling factor (such as 2) to the users of a conversational speech bearer, and another scaling factor (such as 0.5) to the interactive data bearer. The user density distribution is based on the same information, but four times more users are generated for the conversational speech radio bearer than for the interactive data bearer.

Traffic density maps may also be defined individually for each bearer, or traffic demand can be based on a uniform user distribution in a certain area or the whole network.

2.7.12 Definition of a Traffic Demand Mix

In the traffic demand mix the WCDMA bearers, the terminals and the traffic density definitions are linked together to form a combined *traffic demand mix*. This approach ensures that all WCDMA bearers provided by the UTRAN system can be simultaneously simulated in the network plan. In the real UTRAN network each enabled WCDMA radio bearer requires certain air interface resources. TEMS CellPlanner facilitates free mixing of WCDMA bearers, terminals and traffic density maps, thus simulating the real network behavior.

You can plan in different traffic load scenarios by defining several traffic demand mixes and choosing them for different runs of WCDMA analysis.

When defining a traffic demand mix, the following requirements must be met:

- The traffic demand mix must consist of at least one traffic demand
- Each traffic demand must provide a connection between the target radio bearer, a traffic distribution (uniform or based on a traffic density map), and one or more terminal types
- Terminal types linked to the traffic demand must support WCDMA bearers selected as the target in the traffic demand
- If a traffic demand is spread over several different terminal types, the contributions from the terminals must equal 100%.

A traffic demand mix that correctly fills these requirements can be used when running WCDMA analysis with Monte Carlo simulations.

2.8 Concept of Air-Interface Speech Equivalents (ASE)

In GSM systems the capacity of a base station is defined by the number of TRXs available. The air interface capacity of a WCDMA system is a common shared resource between all the users in the network. Depending on the bearer bit rate and QoS class, different bearers require a varying number of resources from the common resource pool. To express the resource pool of the WCDMA base station in clearly defined capacity parameters and to compare capacity figures with existing 2G systems, the term *Air Interface Speech Equivalents* (ASE) is introduced for Ericsson WCDMA equipment.

An ASE is a virtual capacity resource of the air interface in a WCDMA network. It should not be compared directly to a speech channel of a GSM system.

The capacity of a WCDMA base station in terms of ASE depends mainly on the following factors:

DL / UL	Dependent Factors
On the DL	• number of sectors and antenna radiation patterns • Total transmitter output power for each cell • Cell plan • Multi-path fading environment • Availability of transmit diversity
On the UL	• number of sectors and antenna radiation patterns • Receiver noise figure and maximum allowed noise rise for each cell • Cell plan • Multi-path fading environment • Availability of receive diversity

The ASE capacity of a WCDMA base station does not depend primarily on the RBS hardware resources, but on the radio environment, the antennas, and the cell plan applied for the WCDMA system. The virtual capacity measure ASE is used in Ericsson's implementation of admission and congestion control. The dependency between the RBS hardware resources and the number of bearers supported by a base station is explained in the Concept of Channel Elements on page 2-25.

Although you can use several different terminals for spreading the traffic of a specific bearer, it is difficult to interpret the results of WCDMA analysis because the result plots are presented on a bearer level and not on a terminal level. A one- to-one relationship between WCDMA bearers and terminals should be used to clearly distinguish the impact of different terminal types.

2.9 Concept of Channel Elements

Unlike GSM and TDMA systems where the capacity of a base station for user traffic depends on the number of available timeslots and frequency slots (TRX), most hardware resources in a WCDMA RBS (Node B) are shared between all users.

2.9.1 Common Hardware Resources

The following units are common between users on the same carrier frequency and independent of the number of users served by the RBS:

- Power and cooling equipment
- Transmission equipment
- Antenna combiner, feeder and antenna equipment
- Transmitter/Receiver boards on the RF side
- Multi Carrier Power Amplifiers
- Mounting hardware
- Control and O&M hardware and software

The baseband processing part of the RBS is the only hardware resource that strongly depends on the number of users served and the bit rate of the radio bearer provided. With the introduction of a new hardware platform based on the principles of (W)CDMA, the capacity dependent part is located in the digital signal processing section of the RBS hardware.

2.9.2 Definition of Channel Elements in WCDMA

A channel element (CE) is the required baseband processing capacity and hardware for one speech bearer (AMR 12.2 kbps) connection. Mapping the channel element definition to the speech bearer facilitates easy capacity comparison with today's GSM systems that use a similar user data speed on the speech connection.

The capacity requirements for all higher bit rate bearers (both circuit switched and packet switched) are strictly linked to the speech bearer by assigning a larger number of baseband processing resources to those bearers. Ericsson has implemented of channel elements so that the number of channel elements required for higher bit rate services is always an integer multiple of the number of speech channel elements.

The definition of channel elements as the capacity resources in WCDMA radio base stations is not standardized by 3GPP, so differences exist among vendors in expressing base station hardware capacity.

Ericsson's definition of a channel element is linked to Dedicated Channel (DCH) resources of the RBS, only to the resources required for user data handling for the

different radio bearer types. This definition includes both dedicated data channels and dedicated signaling channels. Processing capacity required for common signaling channels and certain radio network functionality is *not* included in the definition of a channel element.

Example: Speech Bearer

Before a speech bearer can be defined, UTRAN provides a dedicated *signaling radio bearer* (SRB) towards the terminal during the call establishment phase. The baseband resources required for that SRB are dedicated resources and, consequently, included in Ericsson's channel element definition.

2.9.3 Functions Handled by Channel Elements

Since the baseband processing algorithms in WCDMA are different for uplink and downlink, the processing requirements on the hardware and software of the RBS in both links are different.

Downlink Baseband Processing

On the downlink the channel element includes the following functions:

Function	Description
CRC handling	User data is processed in a CRC generator and a check-sum is attached to the original user data packet. The check-sum allows bit error detection in the downlink receiver, located in the terminal equipment (UE, mobile).
Channel coding	User data and check-sum are coded to allow bit error correction in the downlink receiver. The radio channel characteristics introduce bit errors into the received data stream. Channel coding facilitates the user data recovery in the presence of bit errors based on convolutional and turbo coding.
Interleaving	Coded data is processed by an interleaver to randomize the occurrence of bit errors in the data stream received by the downlink receiver. Error randomization yields a higher performance for the decoding algorithms under adverse radio channel conditions.
Spreading	The data stream is spread to a wideband signal according to the spreading factor assigned for a certain bit rate of a radio bearer. The spreading improves the frequency diversity properties of the radio signal and yields a processing gain in the downlink receiver.
Rate matching	Operation is performed for high bit rate services to ensure a continuous bit stream within each radio frame. Rate matching can involve both bit repetition and puncturing (bit deletion) for matching the frame length of the coded user data to the radio frame length.

UL Baseband Processing

In the uplink, the RBS carries out all baseband processing relevant for the received user data stream. An uplink channel element handles the following functions:

Function	Description
Signal demodulation and RAKE receiver	The received and frequency down-converted signal is demodulated and the multipath components are combined on a per-user basis in the RAKE receiver.
De-spreading	The demodulated data stream is de-spread in the uplink receiver, resulting in a processing gain for the uplink user data.
De-interleaving	Before the user data can be decoded efficiently in the receiver path, the interleaving applied on the transmit side must be removed first.
Decoding	The user data is decoded in a Viterbi or Turbo decoder and bit errors are corrected. The selection of the coding scheme depends on the bit rate of the radio bearer. It is defined in the 3GPP specification TS 25.212.
CRC evaluation	CRC evaluation facilitates the discovery of bit errors and the generation of error detection feedback information to the mobile terminal transmitter.

The baseband signal processing at the receiver side is more complex and requires more processing power compared to the processing on the downlink.

2.9.4 Concept of Channel Element Pooling

When different technical processes require the same or similar types of hardware and software resources, the available resources can be concentrated in a pool to maximize the efficiency of resource use. Pooling resources yields a capacity gain in environments where an non-homogeneous distribution of resource demands is expected, true for mobile radio networks.

Another important aspect of pooling is the intrinsic redundancy of resources that share the same pool. In the case of WCDMA radio base stations, the traffic demand can be taken over by other resources within the pool when part of the total capacity resource becomes unavailable. Consequently, the availability of traffic handling resources is increased compared to non-pooled resources.

Although WCDMA supports a wide range of radio bearers on different common and dedicated channels, the same baseband signal processing parts within the RBS provide the basic hard- and software resources. To maximize efficiency of the RBS processing capacity, channel elements are provided by pooling available resources.

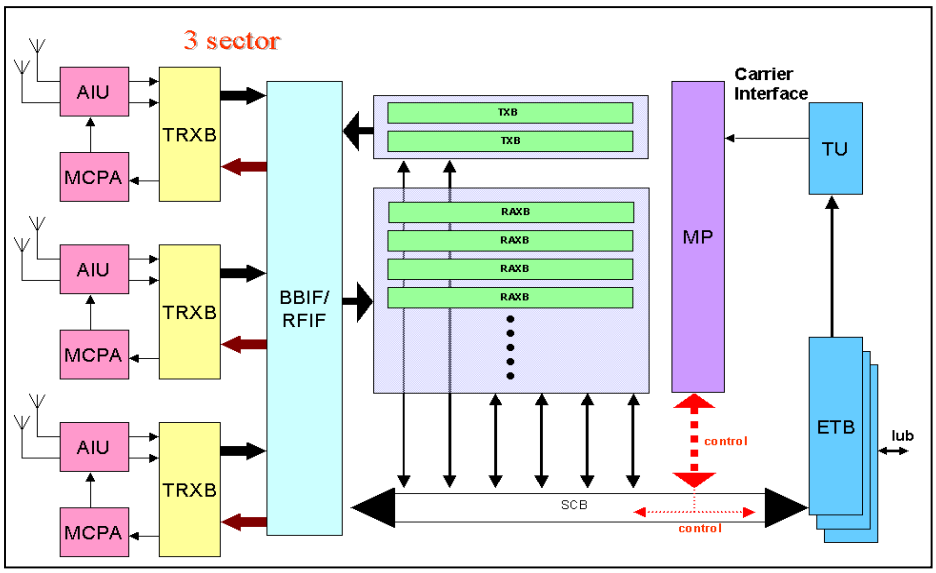
The following types of channel element pooling are identified for WCDMA base stations:

- Channel element pooling over different sectors of the same base station

- Channel element pooling over different frequency layers of the same base station

Pooling Channel Elements over Sectors

Sharing common parts for baseband processing and common BBIF/RFIF for all sectors enables pooling channel element resources over different sectors of the same RBS.



This solution contains a single high capacity BBIF/RFIF-module for interfacing between RF related and baseband related hard- and software of the RBS.

As a result, the same total RBS capacity can be provided with fewer channel elements than if the resources for the different sectors are separated from each other. The pooling gain is maximized through the full (100%) resource pooling.

Pooling Channel Elements over Frequency Layers

The total pooling gain in a WCDMA base station can be further increased, if the hardware architecture allows for a pooling not only over different sectors, but also over different frequency layers of a base station.

Full pooling of resources over different frequency layers can be achieved by sharing the RFIF/BBIF not only between sectors, but also between the different frequency layers. The architecture allows for full pooling of resources for ALL sector carriers within a RBS cabinet.

The additional gain for pooling of resources over frequency layers is in the order of roughly 10% on a per base station level. The ability to pool resources over frequency layers implies a substantial capacity gain for the operator on an overall network level.

2.9.5 Channel Elements and WCDMA Radio Network Planning

The task of the radio network planner is to define the configuration of the RBS to satisfy the requirements for coverage and capacity based on a certain traffic scenario for a WCDMA radio network.

The network planner has to calculate the number of channel elements required for each RBS configuration. The calculation is usually based on a certain traffic scenario for each RBS.

TEMS CellPlanner allows you to define the number of channel elements required for each radio bearer and to calculate the total number of channel elements needed per cell and base station.

The following requirements are taken into consideration by WCDMA analysis when calculating the number of channel elements required per cell and WCDMA bearer:

- The number of channel elements required per cell and bearer depends on the user defined input on required channel elements per rate set for the WCDMA bearer and the number of users served by each cell.
- For calculation of the number of channel elements required per cell and WCDMA bearer the mean value is used of the users served for the respective bearer.
- For calculation of the number of channel elements required per WCDMA RBS and WCDMA bearer the mean number is used of users served by that RBS on the respective bearer.
- Traffic generated in the cells due to softer handover is not be taken into consideration for the calculation of the required number of channel elements, since pooling resources over sectors allows for softer handover combining of channel element resources within a base station (RAKE receiver).
- Traffic generated due to soft handover has an impact on the required number of channel elements. All links involved in a soft handover are considered with the same number of channel elements as defined for the WCDMA bearer/rate set.

You can access the information on the total number of channel elements required per cell and base station from the statistics report of WCDMA analysis, and in the cell information accessed by the WCDMA RBS explorer.

Plots showing the number of channel elements required per cell and link (uplink or downlink) are accessible in the plot manager under the section Channel Independent plots.

Information on the total number of channel elements required per base station and WCDMA bearer is also provided in the output file (*wcp_traffic.out*) for the Ericsson traffic dimensioning tool WCDMA-Transporter.

2.10 Simulating Admission and Congestion Control

Admission and congestion control are vital functions for a WCDMA radio network:

- Admission control helps to avoid overload or congestion situations
- Congestion control acts on a congestion situation and restores network stability.

Since overload or congestion can occur in different instances of the WCDMA system, several mechanisms are provided for admission and congestion control and are active simultaneously.

TEMS CellPlanner provides algorithms to simulate admission and congestion control in a WCDMA system. When an overload situation exists in any part of the simulated network, the algorithms do not permit connection of more users to the overloaded cells. When congestion occurs, the algorithms disconnect some of the users generated in the current trial to restore the stability of the planned WCDMA network.

2.10.1 Simulating Admission Control

During each trial of the iterative WCDMA analysis, user assignment and connection algorithms consider the following admission control parameters for each cell:

- Maximum uplink noise rise limit (maximum uplink load)
- Maximum total downlink power allocation (maximum downlink load)
- Maximum number of ASE consumed on uplink (maximum uplink air interface load)
- Maximum number of ASE consumed on downlink (maximum downlink air interface load)
- Maximum number of SF8, SF16 and SF32 allocated on downlink (maximum code tree use by high bit rate bearers)
- Maximum number of channelization codes allocated on downlink (maximum code tree use by all bearers)

The admission control parameters are set on cell level in the WCDMA RBS explorer, UTRAN Cell - Analysis window.

2.10.2 Maximum UL Noise Rise Limit

While connecting users to the cells the uplink noise level for the cells increases because users connected to the own and users connected to neighboring cells contribute a certain amount of interference. The maximum uplink noise rise limit defines the maximum level of interference increase in dB above the thermal noise

floor level that can be tolerated by the cells in the network. The parameter monitors the maximum uplink load.

2.10.3 Maximum Total DL Power Allocation

The parameter monitoring maximum allocated downlink power is named *Power Admission Factor*, expressed as a percentage of the total downlink power of a cell allocated to common and dedicated channels. The admission control algorithm for downlink power considers power levels assigned to the common channels as well as those allocated to all connected WCDMA bearers (dedicated channels).

2.10.4 Maximum Number of ASEs Consumed on DL

The parameter monitors the downlink air interface load for each cell in terms of allocated air interface speech equivalents (ASE). The parameter is named *Capacity Limit (ASE) DL*. You can set the limits for available downlink ASE on the cell level in the UTRAN cell parameters accessed by the WCDMA RBS explorer. The value depends on the base station configuration, the antenna configuration, the basic cell plan used, and the multipath fading environment. For details on downlink ASE limits for different base station configurations contact the WCDMA system equipment manufacturer.

2.10.5 Maximum Number of ASEs Consumed on UL

The parameter monitors the uplink air interface load for each cell in terms of allocated air interface speech equivalents (ASE). The parameter is named *Capacity Limit (ASE) UL*. You can set the limits for available uplink ASE on the cell level UTRAN cell parameters. The value depends on base station configuration, antenna configuration, the basic cell plan used, and the multipath fading environment. For details on uplink ASE limits for different base station configurations contact the WCDMA system equipment manufacturer.

2.10.6 Maximum SF8, SF16 and SF32 Allocated on DL

The parameter monitors the orthogonal channelization code tree resources by high bit rate services on the downlink for each cell. The spreading factors correspond to the following downlink bit rates for the WCDMA bearer:

Spreading Factor	DL Bit Rate of the WCDMA Bearer
SF8	384 kbps
SF16	128 kbps
SF32	64 kbps

As a general rule, one should not assign more than 50% of the total code tree resources to high bit rate services, resulting in the following maximum figures for SF use:

Spreading Factor	Suggested Maximum Value
SF8	4
SF16	8
SF32	16

2.10.7 Maximum Channelization Codes Allocated on DL

The WCDMA air interface contains a total of 256 downlink channelization codes, called orthogonal spreading codes, available under one primary scrambling code (cell). The resource is sometimes called code tree resource. Depending on the traffic and signalling load in a cell some of the codes out of the total code resource are consumed by signalling channels, such as FACH and PCH.

TEMS CellPlanner includes the code resource utilization in the admission control algorithms. To provide sufficient code resources for the signalling channels and possible handover connections, about 30% of the code resources should be reserved for those channels under all traffic conditions.

Each time a radio bearer is connected to the system the corresponding amount of code resources are occupied by that bearer. Under certain conditions, the number of codes available may not be sufficient to satisfy all connection attempts. In such cases the connection attempt is blocked due to insufficient code resources.

The number of orthogonal codes available for traffic channels is an input parameter to the admission control algorithm in TEMS CellPlanner.

2.10.8 Simulating Congestion Control in TEMS CellPlanner

While calculating uplink and downlink load during the iterations within a trial the congestion control algorithm of TEMS CellPlanner monitors the status of all above parameters. If necessary users are disconnected based on the assigned priority of the WCDMA bearers used for connecting the user to the network.

As a general rule, packet switched bearers are disconnected first. If fallback rates are available for some of the packet switched bearers, then the connection is tried on a fallback rate instead. Only if the overload situation could not be resolved by disconnecting or down-switching users on packet switched bearers, users on circuit switched bearers are disconnected based on bearer priority.

2.10.9 Bearer Connection Status and WCDMA Analysis Statistics

The traffic modeling algorithms of TEMS CellPlanner consider both active and inactive users in the user connection statistics. For calculation of the interference

contribution and load in the air interface, only the active users in each trial are taken into consideration. Since, inactive users would still require certain hardware resources from the WCDMA radio network even during their inactive period for a particular snapshot, the calculation of channel element resources considers both the active and the inactive users.

Users on a packet switched bearer that is set to inactive state during a trial are assumed to be served by the cell(s) in that trial. The number of users served in a cell includes both active and admitted as well as inactive users. Users not admitted to the system or blocked due to any violation of the resource limits are calculated depending on the blocking reason.

If a radio bearer uses multiple bit rates, some of the user connection might be admitted to the system on the fallback rate. The user connection is treated as served and connected on fallback rate.

The WCDMA statistics output file provides details on the bearer connection status and the detailed blocking reasons for all radio bearers simulated. Statistical information is provided on cell, site and WCDMA radio bearer level.

2.11 Handling Log-Normal Fading Margins

Radio propagation models used for pathloss predictions do not capture the long-term or slow fading of a real radio environment. As a result, the coverage probability reaches about 50%, whereas most operators have much higher requirements of 98% to 99,99% coverage probability within their service areas.

To account for long-term fading in coverage planning, a log-normal fading margin is added when performing link budget calculations.

2.11.1 Derivation of Fading Margin

Log-normal fading margins are initially derived from simulations and verified later by field strength measurements in the real network.

The log-normal fading margins to be applied for network planning depend on many factors, the most important of which are:

- Channel properties (radio channel model)
- Area usage (land-use or clutter type)
- Required coverage confidence
- Soft handover gain at cell edges, if there is a possibility to perform soft or softer handover to another cell in the network

2.11.2 Obtain Tables of Fading Margins

Tables of simulated log-normal fading margins for different environment types can be obtained from network equipment suppliers. Replace these values as soon as measured values are available from drive testing in the real network.

In most Excel-based network dimensioning applications, the soft handover gain is merged into the log-normal fading margin to simplify the calculations.

2.11.3 Using Fading Margins

Fading margins are either fixed or random.

Fixed fading margins are implemented as fixed per landuse code. This fading margin is applied to all terminals in the respective landuse category in the same way.

Fading margins are handled differently if you want to perform:

- Non-iterative WCDMA analysis based on fixed load UL and DL values per cell
- Iterative WCDMA simulation using the Monte Carlo simulator

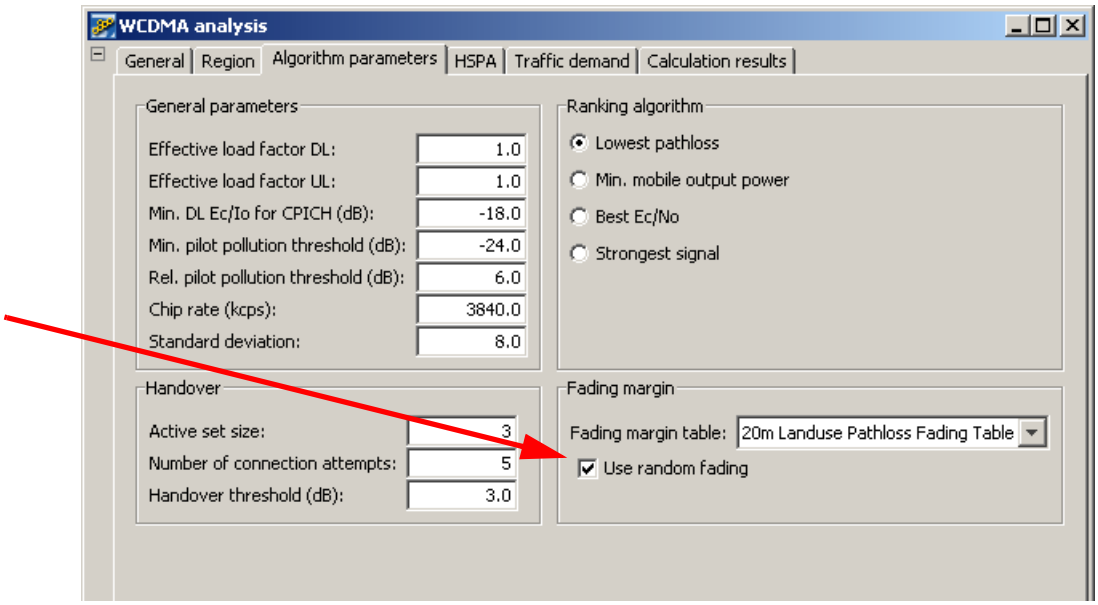
2.11.4 Fading Margins in Non-Iterative WCDMA Analysis

For non-iterative WCDMA analysis, similar fading margins can be applied as those used for network dimensioning. The fading margin is used to provide coverage plots for a higher coverage probability than the average as calculated by the propagation model -- that is, for more than 50% coverage probability.

In most network planning departments good knowledge exists about the fading environment in different parts of the network and the values for fading margins to apply for different landuse types.

2.11.5 Simulating Random Fading

You can simulate random fading in iterative WCDMA analysis by enabling random fading in the **WCDMA analysis - Algorithm parameters** window:



Random fading simulation is used only in the iterative WCDMA analysis.

Depending on the standard deviation values set for landuse codes in the pathloss fading table, radio connections to terminals in the network experience both up- and down-fading. The fading is statistically distributed according to a normal distribution function around the predicted pathloss value. Fading correlation for signals coming from the same site is considered by the simulator.

This approach ensures that the log-normal fading component in the radio signal is simulated in a much more advanced way than by only applying fixed fading margins.

The random fading component is applied to the predicted pathloss value and is used for checking of power resources when setting up connections to the cells in the simulator.

For plot generation only the fixed fading margins defined for UL and DL in the pathloss fading tables are considered. This allows for maximum flexibility to run fading simulation and still be able to produce coverage plots with or without additional fading margins for different coverage confidence targets.

2.11.6 Fading Margins in Iterative WCDMA Analysis

When running iterative WCDMA analysis based on Monte Carlo simulations, the handling of fading margins differs substantially. In this analysis mode terminals try to connect to the network in a random way. The fading for these terminals has a random behavior. While some terminals experience a signal down-fade, other terminals experience a signal up-fade. Signal up- and down-fades are statistically evenly distributed. It is not suitable to apply the same fading margins as for non-iterative WCDMA analysis, since it would result in all terminals experiencing signal down-fades only.

Within the WCDMA coverage area of a network, terminals can enter a soft or softer handover connection. The signal gain associated with soft or softer handover compensates for the fading to a large extent. Only at the coverage borders of a WCDMA network, where no possibility exists to perform a soft or softer handover to another WCDMA cell, the application of fading margins for increased coverage confidence applies.

When running iterative WCDMA analysis without random fading it is suggested to set the fading margins to zero. When you want to simulate, for example, a certain power control headroom, you can do this by assigning a small margin in the range of 0.5 to 1 dB in the fading margin tables. When random fading is selected, the fading margins are ignored, as the random fading standard deviation is used instead.

2.11.7 Log Normal Fading and Soft Handover Gain

TEMS CellPlanner calculates the handover gain for each bin involved in a soft or softer handover and reduces the transmit power required for a connection in a soft or softer handover state. The log-normal fading margins entered in the pathloss fading tables of TEMS CellPlanner do not consider any soft handover gain.

2.11.8 Using Fading Margins in Non-iterative WCDMA Analysis

The non-iterative WCDMA analysis is substantially a plot generation algorithm based upon user-defined uplink and downlink load values per cell.

The uplink and downlink coverage plots are based upon the available cell or terminal output power for the different radio bearers, on the channel quality requirements in terms of Eb/Io, on the pathloss from the cell to a particular position in the network and -if applicable- on a certain fading margin.

In areas where a terminal would enter a soft or softer handover connection a handover gain is applicable. The handover gain compensates to a large extent for signal fading on individual user connections to cells. Consequently, within the coverage area of a WCDMA network no strong need exists to apply large fading margins as is the case in 2G systems.

At the coverage borders of a WCDMA network the possibility for soft or softer handover is not available. To consider a coverage confidence requirement of 95% and above a certain fading margin must be applied.

Random fading is not used in non-iterative WCDMA analysis.

2.11.9 Fading Margin Dependencies

Fading margins depend strongly on the fading environment in the network and on required coverage confidence at the WCDMA network coverage borders.

Most network planning departments have good knowledge of the fading environment in different parts of the network and the values for fading margins to be applied for different landuse types.

2.11.10 Using Fading Margins in Iterative WCDMA Analysis

In iterative WCDMA analysis based on Monte Carlo simulations a snapshot analysis of the network is done. Since Monte Carlo simulations are static simulations, each snapshot provides information only on one particular point in time for the simulated network.

When trying user connections to the network each individual connection is subject to random signal fading. Some user connections experience a signal up-fading, while other connections are subject to down-fading. To simulate the fading behavior in network planning tools, the fading has to be randomized on individual user connections.

If random fading is not selected, applying any fading margins to the individual user connections in the Monte Carlo simulator means all user connections would be perceived as being in down-fades only. Such assumption in not realistic and therefore it is suggested to not apply any major fading margins when running the iterative WCDMA analysis. Therefore, the values for uplink and downlink fading in the pathloss fading tables are set to zero.

In case you would like to simulate a certain power control headroom (margin for fast power control giving fast fading) or any other margins to the individual user connections, it is suggested to apply minor margins in the range of approximately

0.5 to 1 dB. Otherwise the risk exists that the network plan becomes too pessimistic in terms of uplink and downlink coverage and capacity.

Random fading is enabled by selecting the "use random fading" option. For every clutter type, a log-normal distributed random value is generated and stored in a dedicated column of the fade margin table. A given standard deviation is used. The random value is added to the path loss in every link between an NP (UE) and a base station. The random value consists of two terms, where one term is generated once for every UE and used for all links to base stations transmitting to or receiving from the UE, and the second term is generated once for every combination of UE and base station site.

When "use random fading" is selected, fade margins are not applied during Monte Carlo simulations.

When "use random fading" is not selected, fade margins are applied in the Monte Carlo simulation, when connection checks are made considering CPICH quality and required UL and DL power. The margins do not affect the actually assigned UL and DL power.

In both cases, the fade margins are applied in the plot generation.

2.11.11 Impact of Soft Handover on the Fading Margin

The capability of performing a soft handover connection to two or more cells yields a signal gain, also called *soft handover gain*. The gain can be used to reduce the required fading margin for all users in a soft handover connection. The value by which the fading margin can be reduced depends on the link and on the difference in received signal power from the different cells.

On the downlink, soft handover combining takes place in the terminals RAKE receiver by assigning different RAKE fingers to the cells in the active set. The combining method applied is called maximum ratio combining and gives a gain of approximately 3 dB under favorable radio conditions.

On the uplink, soft handover combining takes place in the RNC on the data frame level. The combining method is called selection combining and gives a much lower gain than the maximum ratio combining.

For users in soft handover TEMS CellPlanner calculates the soft handover gain on the downlink from the signal power difference of all cells in the active set, and subtracts the soft handover gain from the fading margin. The fading margin entered for the downlink in the pathloss fading table must not contain any soft handover gain.

On the uplink the soft handover gain is not considered by the algorithms. The fading margin entered for the uplink in the pathloss fading table contains the uplink soft handover gain derived from link level simulations.

2.12 Pathloss Fading Tables

2.12.1 Pathloss, Predictions, and Fading Margins

When using standard macro cell radio wave propagation models, coverage probability is around 50%. Most operators require coverage probability well above 95%. To consider shadow fading and to increase the coverage probability to reach required target values, an additional margin called the *log-normal fading margin* is added to the predicted pathloss.

The accuracy of the predicted pathloss depends on verifying the propagation model and tuning it based on drive test measurements.

2.12.2 Propagation Model Tuning and Puncturing

The fading margin applied should be close to the standard deviation of the predicted pathloss. For a standard macro cell propagation model, the standard deviation is in the area of 6 to 14 dB.

For a propagation model tuned towards local radio wave propagation conditions, the standard deviation can become much lower, around 4 to 6 dB.

Because mobile terminals in a WCDMA network can perform a soft or softer handover when approaching the coverage edge of their serving cell, the fading margin can be further reduced by the handover gain.

It is generally suggested to perform detailed network planning and WCDMA analysis based only on tuned propagation models to minimize the error margin in the predicted pathloss.

TEMS CellPlanner provides the feature of puncturing the predicted pathloss with measured pathloss data, thereby increasing the accuracy of the pathloss data that forms a vital input to WCDMA analysis.

2.12.3 Fading Margins

Using both propagation model tuning and puncturing of pathloss data with drive test measurement data allows network planner to improve accuracy of pathloss data.

Fading margins are applied to increase the coverage confidence mainly for link budget calculations. With a tuned propagation model and detailed map data available to run accurate pathloss predictions, the need for fading margins in the same order as used for link budget calculations decreases.

2.12.4 Fading Margins and Iterative Analysis

It is suggested to not apply fading margins to iterative WCDMA analysis based on Monte Carlo simulations, as described in Handling Log-Normal Fading Margins on page 2-34.

Depending on the required coverage confidence, the resulting fading margin may become negative due to the applied handover gain that compensates for a large part of the long-term fading.

Higher fading margins must be applied when:

- The propagation model cannot be tuned towards the local wave propagation conditions
- There is no reliable drive test measurement data available for puncturing the predicted pathloss values

2.12.5 Fading Margins and Non-Iterative Analysis

For non-iterative analysis, it is suggested to apply fading margins only in the areas that belong to the coverage border of the WCDMA network. Within the coverage area of the WCDMA network, it is suggested to not apply any major fading margins, since handover gain from soft and softer handover compensates for log-normal fading.

When no detailed values exist for fading margins to apply to WCDMA planning your network coverage area, the following initial values could be applied:

Environment	σLNF (dB)	Area Coverage (%)		
		90	95	98
Rural, suburban	6	0.5	1.5	3.5
Urban	8	0.9	2.7	5.3
Dense urban, suburban indoor	10	1.5	5.1	7.9
Urban indoor	12	2.8	6.5	11.2
Dense urban indoor	14	3.7	8.5	13.4

2.13 Handling Soft and Softer Handover

The ability to perform a soft or softer handover connection to two or more cells in the network yields a signal gain, called *soft handover gain*.

2.13.1 Handover Gain

One of the features of WCDMA networks is the ability to provide soft and softer handover:

Handover Type	Mobile Terminal Condition
Soft handover	Mobile terminal connected to two or more cells belonging to different base station sites
Softer handover	Mobile terminal connected to two cells belonging to the same base station
Soft-softer handover	Mobile terminal in soft and softer handover state at the same time.

The ability to perform a soft or softer handover to a neighboring cell when the mobile terminal is close to the coverage edge of the serving cell leads to a gain in signal quality. When there is no possibility of handover, a gain in signal quality cannot be obtained.

2.13.2 Gain Depends on Link and Type of Handover

The handover gain that can be achieved depends on the direction of the radio link and the type of handover performed. The following table shows example values on the gain in different handover situations:

Gain	Soft Handover	Softer Handover
Uplink gain	1.5 dB	3.0 dB
Downlink gain	3.0 dB	3.0 dB

Handover gain is taken into consideration in TEMS CellPlanner for all positions in the network that are in a handover state in the following way:

- Soft handover gain is calculated on the received signal quality for both uplink and downlink.
- Soft handover gain is calculated for the downlink only based upon the received signal quality. For the uplink the selection combining gain is not taken into account, as the combining takes place in the RNC.

2.13.3 Handover Gain Depends on Combining Method

The ability to perform a soft or softer handover connection to two or more cells in the network yields a signal gain, also called soft handover gain.

Handover gain leads to a possible reduction of the transmit output power on uplink and downlink. The amount of handover gain by which the transmit power can be reduced depends upon the combining method for the radio links in the respective receiver or receivers, and on the difference in received signal power from the handover cells.

On the downlink, the soft or softer handover combining takes place in the RAKE receiver of the terminals by assigning different RAKE fingers to the signals coming from the cells in the active set. The combining method applied in the RAKE receiver on the downlink is called *maximum-ratio combining*. Under favorable radio conditions the handover gain for the combining method is in the order of 3dB.

On the uplink, the handover gain for terminals in soft handover is different from the handover gain for terminals in softer handover. The uplink signal combining in a softer handover connection takes place in the RAKE receiver of the WCDMA base station, and a similar signal gain as in the downlink can be expected.

In the soft handover case the uplink signal combining takes place on the baseband level in the RNC. The combining method applied is called *selection combining*, implying that the signal with the best quality (least BER and FER) is selected for the connection. Selection combining does not offer the same signal gain as maximum ratio combining. Under favorable radio conditions the handover gain for the combining method is in the order of 1.5dB.

2.13.4 Maximum Ratio Combining in TEMS CellPlanner

TEMS CellPlanner considers both soft and softer handover for uplink and downlink connections. Maximum ratio combining is considered by calculating the sum of the signal contributions from all radio links in the active set. This leads to a higher achieved C/I for in the receiver. As a result the transmit power of the transmitter or transmitters involved in the handover connection is reduced. The transmit power reduction achieved in such case depends on the number of links contributing to the maximum ratio combining and on the difference in the received signal C/I between the different radio links.

Maximum ratio combining is applied in TEMS CellPlanner for:

- Downlink connections in soft and softer handover
- Uplink connections in softer handover.

2.13.5 Selection Combining in TEMS CellPlanner

Selection combining evaluates the achieved C/I from individual radio links involved in uplink soft handover. Only the maximum achieved value from the available radio

links is considered for further processing. The transmit power reduction that can be applied to radio links after selection combining is not in the same order as for the maximum ratio combining method, since the received C/I of only the strongest linked is decisive for further calculations.

Selection combining is applied in TEMS CellPlanner for uplink connections in soft handover.

2.13.6 Handling Combined Soft and Softer Handover

In some cases terminals may be in soft and softer handover connections at the same time. The algorithms consider such situations by:

- Calculating the achieved C/I for all radio links that are subject to maximum ratio combining
- Defining the maximum C/I for all radio links that are subject to selection combining
- Applying the maximum achieved C/I from both maximum ratio and selection combining for further processing.

TEMS CellPlanner calculates the handover gain for all types of handover connections (soft, softer, soft-softer) automatically without the need for further definition of assumed handover gain values.

2.14 Principles for Optimizing Scrambling Codes

In WCDMA networks, cells are identified by:

- Unique cell ID
- Frequency
- Scrambling code

Mobile terminals must clearly identify each cell in the network before making a connection attempt. Because all base stations belonging to the same frequency layer transmit on exactly the same frequency, identification based on cell frequency is impossible. Cell identification in WCDMA is done by the cell scrambling code as defined in the 3GPP standards.

Scrambling code optimization is an important task in designing and deploying a WCDMA network. Scrambling codes separate transmissions from WCDMA base station cells on the same radio frequency, so any ambiguity in allocating scrambling codes in the network must be avoided.

2.14.1 Available Scrambling Codes

The total primary scrambling codes available in the WCDMA system is 512. Most networks contain more than 512 cells, so scrambling codes must be reused in the network. Any scrambling code reused in the network must not create a pilot conflict in which a mobile terminal receives signals from two cells using the same scrambling code.

2.14.2 Using Channelization Codes

Channelization codes separate transmissions from the same transmitter on communication channels (common channels and traffic channels). Provided that individual transmitters are assigned different scrambling codes, the channelization codes (256 in total) are re-used in each transmitter.

2.14.3 Single Cell View

Individual cells use channelization codes to separate users and communication channels:

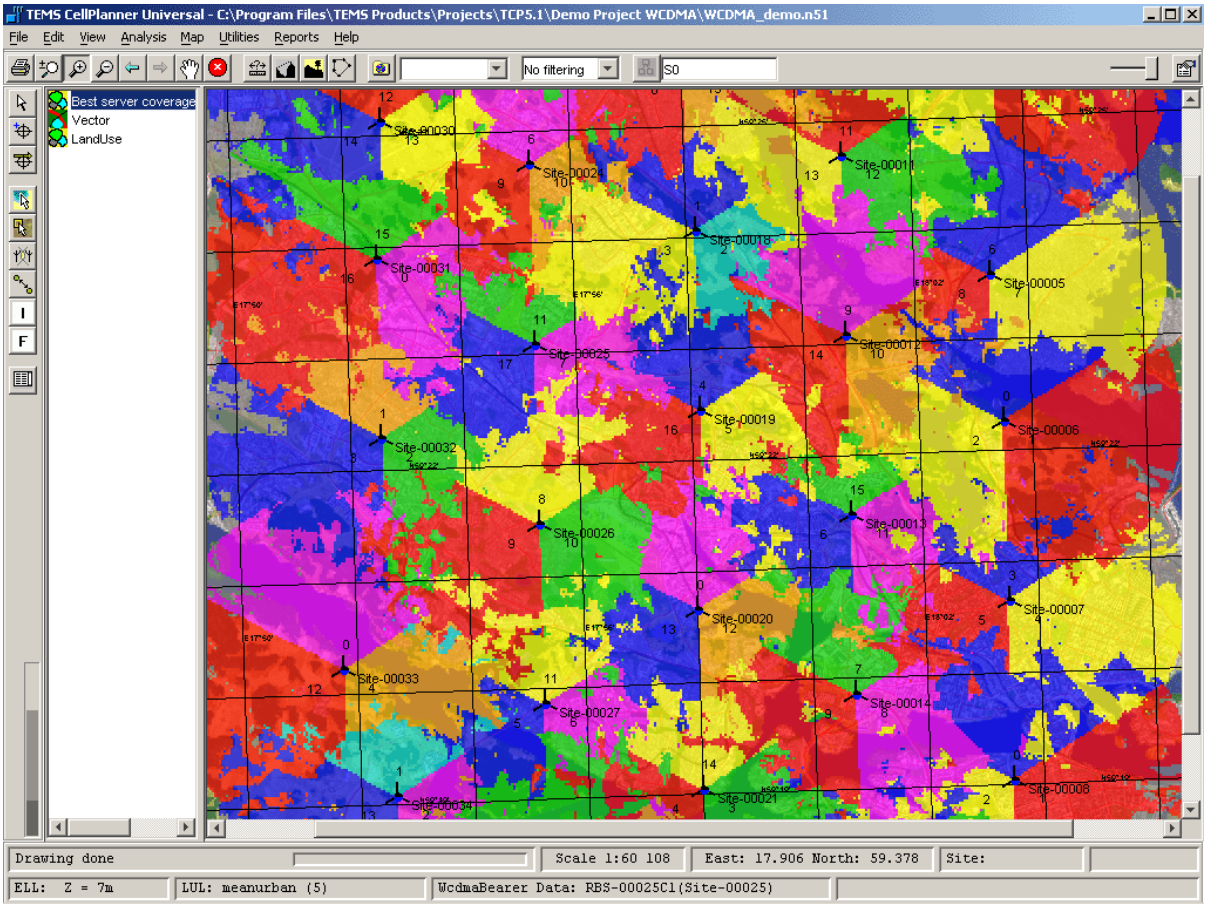
- All mobiles share the same frequency carrier.
- Cells use orthogonal channelization codes to separate users and separate communication channels -- one user (multi-code operation) with inner codes and inner technology.

2.14.4 Network View

The network uses scrambling codes to distinguish between communication channels. Multiple transmitters (RBS, UE) coexist on the same frequency and in the same geographic area. Nearly orthogonal scrambling codes distinguish between communication channels from transmitters -- outer codes, outer technology.

2.14.5 Example Scrambling Code Optimization

The following figure shows an example of scrambling code optimization. The cell scrambling code is the figure adjacent to the cell symbol. Each cell in this example is assigned a unique scrambling code.



2.14.6 Scrambling Codes and Code Groups

The 512 scrambling codes are grouped in 64 groups with 8 codes in each group. Although the auto- and cross-correlation properties of all 512 codes are similar, some operators prefer to allocate scrambling codes in a code group manner. To

support code groups, scrambling code optimization allows you to assign or reserve individual codes as well as code groups.

Some operators prefer to allocate codes from the same code group to cells belonging to the same frequency layer and site. Other operators want to avoid such an allocation scheme and use codes from different code groups for cells on the same frequency layer and site.

2.14.7 Parallel and Independent Code Allocation

As the traffic in WCDMA networks increases, most operators are introducing a second or third frequency layer in the WCDMA system. The application of several WCDMA frequency layers creates hierarchical cell structures in WCDMA. Whenever several frequency layers of a WCDMA network cover the same geographical area, there are differences in code allocation strategy for the different frequency layers.

One approach is to use parallel code allocation, which implies that the code allocation for all frequency layers is identical. This option is used in cases when a second frequency layer has been added to an existing network and a large part of the existing sites have been re-used for the second frequency -- the new cells cover the same geographical area as the existing cells.

When the second frequency layer is used in a hierarchical cell structure, the geographical area coverage differs between the cells in the different frequency layers. Consequently, the operator wants to optimize scrambling codes independently for the two frequency layers.

2.14.8 Reserving Scrambling Codes

During initial deployment of a WCDMA network it is suggested to not use all 512 scrambling codes. As a network matures, the need may develop for additional sites for coverage or capacity in an existing WCDMA service area. To avoid re-allocating scrambling codes for existing cells, it is suggested to reserve some scrambling codes or scrambling code groups for later use.

Reserving scrambling codes may become necessary when optimizing national border areas. In these areas, operators from neighboring countries may use the same radio frequencies. Careful selection of possible scrambling codes for such border areas must be made and agreed upon with the operator of the neighboring country to avoid strong co-channel interference between the two networks.

Optimizing scrambling codes for a nationwide network can be very complex. It is suggested to divide the network into smaller service areas and to run scrambling code optimization separately for these areas. In this case it is also advantageous to reserve scrambling codes or code groups for the areas.

2.14.9 Cost in Scrambling Code Optimization

Similar to optimizing frequencies, optimizing scrambling codes analyzes the cost function and an optimization function to allow maximum code re-use in the network under different constraints. The cost function for the scrambling code algorithm in TEMS CellPlanner takes the following parameters into account:

- Minimum requirement on S/I between different cells with the same scrambling code
- Minimum requirement for Ec/Io for cells with the same scrambling code
- Constraints in scrambling code allocation resulting from the neighbor list of the deployed network
- Constraints in code group allocation schemes for cells at the same site

2.14.10 Minimum Signal-to-Interference Ratio

A distant cell with the same scrambling code allocation as the cell under consideration will create co-channel interference for a mobile terminal under certain conditions. The mobile terminal may be able to detect the same scrambling code from two different cells, which will lead to a pilot conflict with strong interference.

The cost function for minimum S/I monitors the ratio of the RSCP from the own cell to the RSCP from other cells to define, whether or not a certain scrambling code can be re-used for the cell. The default setting for this parameter is 24 dB, which implies that the same scrambling code can be re-used if all other cells are received in the best server coverage area of the cell under consideration with an RSCP of at least 24 dB below the own cell RSCP.

2.14.11 Minimum Pilot Channel Quality Ec/Io

Most mobile terminals have a pilot detection threshold in the range of -18 to -20 dB for Ec/Io pilot channel quality. A mobile terminal in the coverage area of its serving cell cannot detect a pilot signal from a distant cell that is using the same scrambling code as the serving cell if the Ec/Io of the distant cell is substantially below the pilot detection threshold.

In such case the distant cell and the serving cell can use the same scrambling code.

A distant cell received with a pilot quality far below the pilot detection threshold can still cause substantial interference in the serving cell. For that reason the cost function for the scrambling code optimization algorithm also includes the minimum S/I requirement.

2.14.12 Neighbor List Constraints

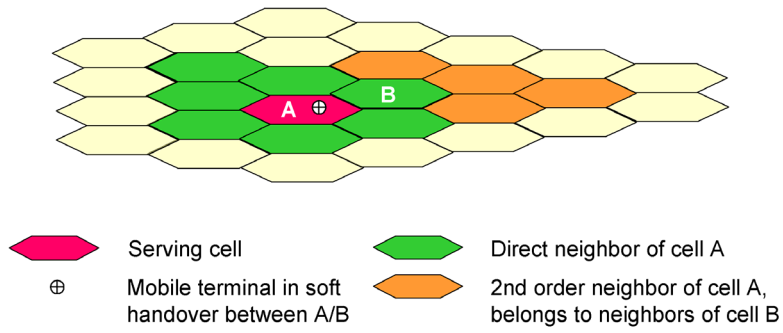
Neighboring cells must not use the same scrambling code as this results directly in pilot conflict. The TEMS CellPlanner scrambling code allocation algorithm considers results from neighbor lists when allocating codes.

A special situation arises when a mobile terminal is in soft and/or softer handover. The maximum length of the neighbor list (intra-system neighbors) in the mobile terminal is limited to 32 entries. The neighbor lists of all cells involved in the soft and/or softer handover connection are merged to one list. In this case, none of the neighboring cells for all cells participating in the handover connection (active set) should be assigned the same scrambling code.

2.14.13 Direct Neighbors and Second Order Neighbors

The optimization algorithm also checks for violations of the neighbor criteria in a handover situation while allocating scrambling codes to cells. You can set a cost value for violation of direct or second order neighbor relations when allocating scrambling codes. Second order neighbors can be excluded from the cost function by setting the cost value for this criteria equal to zero.

A scrambling code must not be re-used for the neighbor's neighbor cell (referred to as a "second order neighbor cell"). This could result in pilot conflict when merging neighbor lists in a soft or softer handover connection, although this requirement is somewhat softer than the constraints applied to direct neighbors. The following diagram illustrates the principle of direct neighbors and second order neighbors:



2.14.14 Code Group Constraints

The cost function of code optimization considers code group options. You can force code assignment from the same scrambling code group to cells on the same site and frequency layer. When this constraint is not met, there is a penalty for cost for the scrambling code assignment of the respective site.

You can force assignment of scrambling codes from different groups to cells of the same site and frequency layer. If this constraint is not met, there is a penalty for cost for the scrambling code assignment of the respective site.

2.15 Principles of Pilot Power Optimization

The common channels in the WCDMA air interface are not power-controlled. Very careful consideration must be given to the actual power level assigned to all the common channels in the network.

The common pilot channel (CPICH) can be regarded as one of the most important channels, since it is used for handover evaluation and as a DL phase reference for all mobiles in idle or common channel mode. For that reason power setting and optimization for CPICH is considered a main operation in TEMS CellPlanner.

2.15.1 Optimizing Pilot Power

In WCDMA networks the risk for pilot pollution must be considered carefully. Pilot power optimization allows you to assess and avoid pilot pollution. Since the power setting of all common channels of the WCDMA air interface is related to the power level of the pilot channel, power optimization adjusts power settings for all common channels as well.

RSCP Plots for Pilot Power

TEMS CellPlanner allows you to display and print plots for received signal code power (RSCP) for the pilot channels in the coverage area of the planned network. A detailed analysis of pilot coverage in the network is provided in the earliest planning stages, allowing you to compare drive test data from pilot measurements in the network with the planned data. This facilitates accurate network deployment and initial tuning of the WCDMA system.

2.15.2 Common Channel Power Settings

Power settings for all common channels are initially made under Utilities↗ WCDMA RBS Explorer↗Cell↗Common channels, including the power level for CPICH and the relative power settings for all other common channels.

Network design normally begins with the same power level on the CPICH for all cells. In the final design, the WCDMA bearer coverage of the cells depends on the traffic load for these cells. In many cases, the WCDMA bearer coverage of the best serving cell is much less than the CPICH coverage of that cell. For handover planning it is vital that the service areas of the cells overlap to a certain extent. With CPICH coverage much larger than the actual WCDMA bearer coverage this leads to a strong overlapping of CPICH coverage from cells. The result of such approach is strong pilot pollution and degraded system capacity.

In these cases it is suggested to balance the power of the CPICH (and all other common channels) toward the WCDMA bearer coverage.

2.15.3 Common Channel Power Optimization

Power optimization allows you to adjust the power of the common channels by a specific margin towards the WCDMA bearer coverage. The margin defines the balance of coverage between the common channels and the WCDMA bearer.

You can optimize pilot power individually for each cell or globally for all cells in the network. When you optimize power for individual cells, the minimum difference between CPICH and WCDMA bearer coverage for each individual cell is taken as a base for the optimization algorithm. When you optimize pilot power globally for all cells, the minimum difference between the CPICH and the WCDMA bearer coverage of the cell with the weakest CPICH coverage is taken as a base for the algorithm.

The value for the "wanted minimum Ec/Io (dB) defines the required CPICH quality at the cell's service coverage area that should be achieved after power optimization.

2.15.4 Initial CPICH Power Settings

Some network equipment vendors recommend deploying the WCDMA network with the same initial CPICH power settings for all cells in the network. The individual power values are then adjusted during initial network tuning to match the actual achieved WCDMA bearer coverage in the live network.

2.16 Area Configurations in WCDMA Networks

Area configuration is used in WCDMA networks to set up location area, routing area, service area and UTRAN registration area information.

Area configuration information is stored in both the RNC and the core network. It is based on assigning an area code to individual cells. Since the mobile terminal can be in idle and RRC connected modes, the control over the mobile must be organized between the core network and the RNCs.

2.16.1 WCDMA Service States

In WCDMA the following service states can be distinguished:

Service State	Description
Idle mode	When a mobile terminal is in Idle mode only the core network (CN) has control over it. The CN uses the PCH channel to contact the terminal and the terminal uses the RACH channel to contact the CN. All signaling is in transparent mode, so that UTRAN passes the information forward only to the core network. The same channels are used to change the mode of the mobile terminal and to establish a Radio Resource Controlled (RRC) connection.
RRC connected mode	When the mobile terminal is in RRC connected mode UTRAN has established a mobile terminal entity in the UTRAN system. UTRAN can still forward information between the terminal and the CN, and can also signal UTRAN internal information between the terminal and UTRAN, information such as resource and mobility control information required to control and maintain the RRC connection.

2.16.2 Cell-Based Positioning

One positioning method used in UMTS is cell-based positioning. This method stores the best server coverage area of each WCDMA cell in the WCDMA network and uses it for positioning mobile terminals.

Cell-based positioning is fully supported by TEMS CellPlanner. After performing the detailed coverage and capacity analysis, you can generate and display polygon information for the best server coverage area of individual cells. This information is stored with other cell based network configuration data.

2.16.3 Mobility Areas

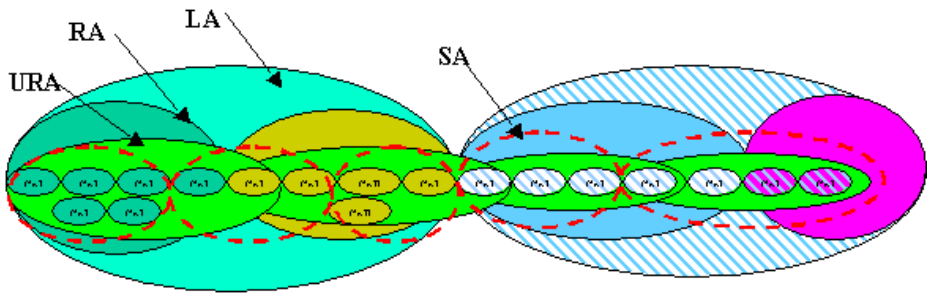
Due to user mobility and unpredictable user behavior in initiating and receiving calls, a risk exists that the WCDMA network cannot determine the location of a specific mobile terminal in the network. The network requires the definition of areas to support localization of all terminals independent of their service state.

A structured definition of mobility areas decreases the time delay whenever the system needs to locate the terminal, for example, when someone is calling a mobile subscriber terminal.

The smaller the location area, routing area, and UTRAN registration area, the shorter the signaling time delay becomes. Fewer cells must send out a page message to find the mobile terminal. On the other hand, if the mobility areas are made too small they create a high signaling load over the air-interface.

Illustration of Mobility Areas in a WCDMA Network

The following illustration shows the mobility areas in a WCDMA network:



2.16.4 Area Codes and Sub-Codes

The area code for each cell contains the following sub-codes:

- LAC - location area code
- RAC - routing area code
- SAC - service area code

In TEMS CellPlanner, you can manually assign area codes to individual cells and display area configuration data.

Location Area

A *location area* consists of a number of cells and is used by a WCDMA network to page terminals in all cells in the location area on request from the circuit switched core network. Location area may be configured only in RNCs connected to one and the same circuit switched core network. One and the same location area may be configured in more than one RNC, and the location area can span several RNCs.

Service Area

A *service area* consists of a number of cells. It is used by the WCDMA network to indicate the location of the terminal to the core network. It is also used by the core network to indicate the area to which core network information should be broadcast.

Routing Area

A r*outing area* consists of a number of cells. It is used by the WCDMA network to page mobile terminals on request from the packet switched core network. The routing area may be configured only for RNCs connected to one and the same packet switched core network.

UTRAN Registration Area

The *UTRAN registration area* consists of a number of cells. It is used by UTRAN to locate user equipment in URA_PCH mode. This area type is not supported in TEMS CellPlanner.

2.16.5 Area Interdependencies

When defining location area, service area, and routing area, the following limitations must be considered:

- Each cell must refer to a location area, a routing area, and a service area.
- Cells belonging to the same routing area or service area must belong to one and the same location area. A routing area or service area cannot consist of cells belonging to different location areas.
- A service area may consist of cells belonging to different routing areas.
- Cells within a location area, routing area, or service area can belong to different RNCs.
- One and the same location area, routing area, and service area may be configured in one or more RNCs. This is because the core network must be able to page a mobile terminal in more than one RNC if required.

3
Using HSPA in WCDMA Networks

This chapter describes TEMS CellPlanner support for HSPA, and provides suggestions for implementing HSPA in a WCDMA network plan.

Topics **Page**

Introduction to HSPA 3-2
HSPA Definition and Evolution 3-2
Maximum HSPA Bit Rates 3-2
3GPP Specifications for HSPA 3-3
Terminology of HSPA 3-4
Channel Structure of HSDPA 3-5
Illustration of Channel Structure 3-5
Connection Set Up and Control 3-5
HSPA Features 3-6
Shorter Transmit Time Interval of HSPA 3-6
Fast Hybrid ARQ with Soft Combining in HSPA 3-6
Fast Link Adaptation of HSDPA 3-7
Efficient Cell Power Utilization in HSDPA 3-8
HSPA Terminals 3-10
HSDPA Terminal Categories and Parameters 3-10
EUL/HSUPA Terminal Categories 3-11
Recommended Terminal Combinations 3-11
HSPA Planning Methodology 3-12
HSPA User Generation 3-12
Power Allocation for HS-SCCH and HS-DSCH 3-12
HSDPA Peak Data Rates and Cell Throughput 3-13
Impact of HSDPA in Existing WCDMA Networks 3-13
Impact on Uplink Coverage and Capacity 3-13
Impact on Downlink Coverage and Capacity 3-14
Impact on Channelization Code Resources 3-14
How to Integrate HSPA in a WCDMA Network Plan 3-15

3.1 Introduction to HSPA

With TEMS CellPlanner you can model your network and terminals to comply with R99 (no HSPA), HSDPA only, HSPA or Evolved HSPA.

3.1.1 HSPA Definition and Evolution

R99 R99 is the basic UMTS standard.

HSDPA High Speed Downlink Packet Access (HSDPA) is a protocol extension of the R99 standard. HSDPA provides higher bit rates and lower latency in downlink. The shared downlink physical channel HS-DSCH allows for a more efficient radio resource usage in HSDPA-enabled cells. The increased power consumption in networks with HSDPA deployed over large areas must be considered when planning, implementing, and optimizing the WCDMA network.

EUL (HSUPA) Enhanced Uplink (EUL), or High Speed Uplink Packet Access (HSUPA), is the corresponding protocol extension for uplink as HSDPA is for downlink. EUL provides higher bit rates and lower latency in uplink.

HSPA High Speed Packet Access (HSPA) equipment supports both HSDPA and EUL.

Evolved HSPA Evolved HSPA, also called HSPA+ or HSPA Evolution, increases the throughput by efficient modulation schemes and antenna techniques:

- 64QAM modulation in downlink
- 16QAM modulation in uplink
- 2x2 MIMO antennas, or tx diversity with 2 tx antennas
- 64QAM modulation in downlink can be combined with 2x2 MIMO antennas for maximized throughput

3.1.2 Maximum HSPA Bit Rates

The achieved bit rates in a live network are limited by the capabilities of the cells and the terminals. To obtain a certain throughput, both the serving cell and the UE must be capable of that throughput.

In downlink, the theoretical maximum bit rate on layer 1 is as follows:

- 14.4 Mbps with HSDPA (16QAM and 1 tx antenna)
- 21.1 Mbps with Evolved HSPA (64QAM and 1 tx antenna)
- 28 Mbps with Evolved HPSPA (16QAM and 2x2 MIMO antenna)
- 42.2 Mbps with Evolved HSPA (64QAM and 2x2 MIMO antenna)

In uplink, the theoretical maximum bit rate on layer 1 is as follows:

- 5.8 Mbps with EUL (QPSK)
- 11.8 Mbps with Evolved HSPA (16QAM)

3.1.3 3GPP Specifications for HSPA

The air interface support for HSPA is specified by 3GPP in standards releases 5 and 6 where new and enhanced DL and UL channels are introduced for HSDPA and EUL respectively. Evolved HSPA is specified in 3GPP standard release 7.

TEMS CellPlanner focuses on the functions specified in standards release 5, 6 and 7 of 3GPP, with full support of Evolved HSPA as specified in release 7.

The network planner can plan for HSPA service rollout in a WCDMA network by considering both ordinary dedicated traffic channels (according to 3GPP release R'99) and HSPA users simultaneously in the same network plan.

For a detailed description of HSPA functionality in WCDMA systems and terminals, refer to the relevant 3GPP standards.

3.2 Terminology of HSPA

The following list presents some of the terms used with HSPA implementation in a WCDMA network:

Term	Definition
16QAM	16-symbol Quadrature Amplitude Modulation
64QAM	64-symbol Quadrature Amplitude Modulation
3 GPP	3rd Generation Partnership Project
A-DCH	Associated Dedicated Channel
ARQ	Automatic Repeat Request
CQI	Channel Quality Indicator
E-DCH	Enhanced Dedicated Channel
EUL	Enhanced UpLink
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
HS-DPCCH	High Speed Dedicated Physical Control Channel
HS-DSCH	High Speed Downlink Shared Channel
HS-SCCH	High Speed Shared Control Channel
Kbps	kilobit per second
Mbps	Megabit per second
MIMO	Multiple Input Multiple Output
NodeB	WCDMA radio base station
P-CPICH	Primary Common Pilot Channel
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
R'99	3GPP Release 1999 specific
RNC	Radio Network Controller
SF	Spreading Factor
SIR	Signal to Interference Ratio
TFRC	Transport Format and Resource Combination
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
WCDMA	Wideband Code Division Multiple Access

3.3 Channel Structure of HSDPA

The HSPA air interface comes with a new channel structure, selected by 3GPP in a way that co-existence of existing release 99 channels with the HSPA channels is feasible.

3.3.1 Illustration of Channel Structure

The channel structure for HSPA is shown in the following illustration:

The main channel is a high-capacity downlink channel that can be shared in both the time and the code domain by several users - the High Speed Downlink Shared Channel (HS-DSCH).

3.3.2 Connection Set Up and Control

For connection set-up and control each HSPA user is connected to the system on a dedicated uplink or downlink channel associated to the HS-DSCH. The A-DCH carries control information to the terminal equipment on the downlink and provides a fast connection between terminal and Node B on the uplink for transmission of channel quality feedback information to the Node B. The CQI measurement reports are sent from the terminal to Node B on the High Speed Dedicated Physical Control Channel (HS-DPCCH) mapped to the A-DCH. As the A-DCH is terminated in the Node B, this channel cannot support soft handover to cells of a different Node B as it is possible for R'99 traffic on DCH. Only softer handover connections to cells within the same Node B are supported.

A separate downlink channel - the High Speed Shared Control Channel (HS-SCCH) is provided to all terminals on the downlink and carries information from the fast link adaptation and scheduling algorithms to the terminals. 3GPP specifies up to four HS-SCCH channels per cell that can also be power controlled. It can be assumed that the first system and terminal releases for early deployment of HSPA support only one SCCH without power control. The HS-SCCH is initially similar to the common pilot channel (P-CPICH) to allow for certain simplifications in planning algorithms.

3.4 HSPA Features

3.4.1 Shorter Transmit Time Interval of HSPA

One of the main enhancements with HSPA is the introduction of a shorter transmit time interval (TTI) of just 2 ms in the air interface. The throughput of EUL terminals using 2 m TTI is higher compared to non-EUL terminals sending with 10 ms TTI.

The shorter interval allows efficiently run radio related functions in the air interface with a much shorter feedback time than was possible in earlier releases, including:

- Fast link adaptation
- Hybrid ARQ
- Radio channel quality dependent user scheduling

A shorter TTI allows adjusting the properties of the transmission on the HSDPA downlink channel 500 times per second and has the following advantages:

- Fast changing radio channel conditions (mainly due to fading and multipath propagations) can be tracked by the radio functions more accurately.
- Scheduling of users and data packets can be realized much more efficiently, since it is now possible to receive a fast feedback on the instantaneous radio channel conditions for individual users.
- By reducing the round-trip time for packets in the air interface, the application response time is perceived as improved service quality and as a higher data throughput for the application in the terminal equipment.

3.4.2 Fast Hybrid ARQ with Soft Combining in HSPA

The fast changing quality of any radio channel introduces bit errors in data packets sent between the transmitter and the receiver of a packet transmission. In traditional error correction schemes for interactive and best effort data transmissions, the solution is to automatically request a re-transmission (ARQ) of the erroneously received packets. Expecting the retransmitted packet to arrive without bit errors, the previously received erroneous packet is discarded.

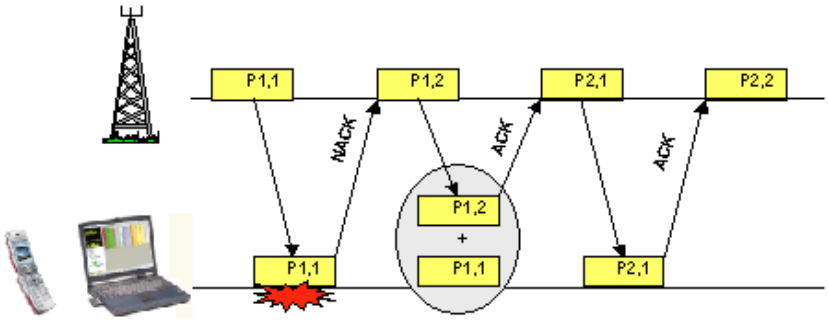
Soft-Combining Packets

In HSPA both the erroneous packet as well as the re-transmitted packet are soft-combined together by the error correction algorithm to more efficiently use earlier sent packets and air interface resources. By deploying Hybrid ARQ with soft combining, the air interface capacity can be increased while keeping a high robustness of the error correction schemes. The main advantages of this feature are:

- Drastically reduced round-trip time. Since the fast re-transmission of erroneous packets is handled by the NodeB rather than the RNC, the response time for the packet re-transmission is reduced.
- The error correction coding can be adjusted to the bit rate properties of the radio channel in a fast manner. This leads to an improved performance and robustness of the radio connection.
- You experience a higher data throughput in the application as well as a faster application response time.

Multiple H-ARQ Processes

Multiple H-ARQ is the ability to store consecutively sent packets from the transmitter in the receiver (UE), without the need to wait until erroneous packets have been received without errors. This principle realized by multiple H-ARQ processes to the same terminal is depicted in the following figure. It allows a dramatic increase in the use of the air interface resources and increases the system throughput.



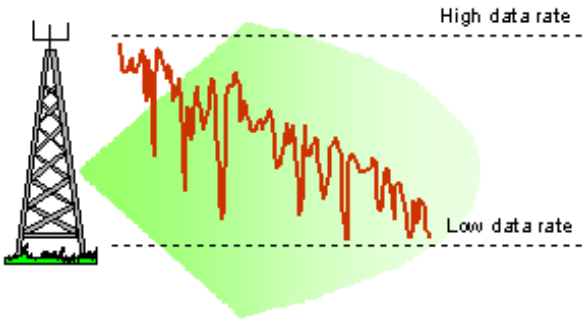
3.4.3 Fast Link Adaptation of HSDPA

Based on the 2 ms TTI and a new feedback channel from the UE to the system for reporting of the instantaneous radio channel quality Channel Quality Indicator (CQI), the transmission parameters, such as error correction coding scheme and modulation scheme, can be adjusted so as to track fast varying radio channel conditions.

Fast link adaptation takes advantage of good radio channel conditions to employ a higher order modulation scheme of 16 QAM and increase the downlink peak data rate by a factor of 2 as compared to the ordinary (3GPP Release 99) Quadrature Phase Shift Keying (QPSK) modulation on the downlink.

Instead of compensating for rapidly varying radio channel conditions by using power control, the HSDPA downlink channel relies on rate adjustment while the transmission power is kept constant. The data rate adjustment is achieved by changing the channel-coding rate. This is also known as rate adaptation and is more efficient than power control for all services that tolerate short-term variations in the data rate.

The principle of fast link adaptation for HSDPA is depicted in the following figure:



Parameters Adjusted by Fast Link Adaptation

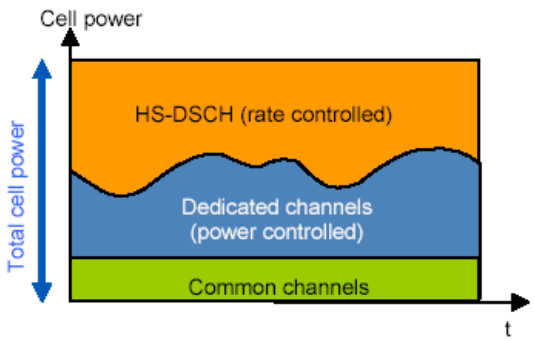
The following transmission parameters are adjusted by the fast link adaptation:

- Modulation scheme
- Error correction coding rate
- Allocated SF=16 channelization codes

Besides radio channel quality, the cell power available for HSPA transmission is considered by the fast link adaptation.

3.4.4 Efficient Cell Power Utilization in HSDPA

Fast link adaptation considers the cell power available for HSDPA downlink transmissions. Rather than deploying power control for compensating adverse radio channel conditions, the HSDPA downlink shared channel is rate controlled. This allows use of all remaining power of a cell up to the power limit of the MCPA and after that the R'99 traffic demand has been satisfied in a cell for HSPA transmission.



Consequently, no urgent requirement exists to deploy a second or separate carrier for HSPA. The currently unused power resources in a cell can be used to provide HSPA transmissions on existing carriers. This facilitates efficient resource sharing between delay sensitive services (conversational and streaming) with packet data

services (interactive and background types) that are not as delay sensitive on the same frequency carrier.

As the traffic demand on HSPA channels increases, WCDMA deployment strategy will be revised due to a high load on the HSPA channels having an impact on the existing R'99 traffic channel coverage and capacity.

3.5 HSPA Terminals

HSPA terminals are categorized according to their downlink and uplink limitations as specified in HSDPA Terminal Categories and Parameters and EUL/HSUPA Terminal Categories.

3.5.1 HSDPA Terminal Categories and Parameters

3GPP has standardized 20 terminal categories for HSDPA support. Depending on modulation scheme, number of orthogonal codes, minimum inter TTI interval and soft buffer size supported, the terminals allow for a downlink peak bit rate on the physical layer of up to 42 Mbps.

Terminal Category	Max # Codes	Min Inter-TTI Interval	Layer 1 Peak Rate [Mbps]	Modulation Schemes without MIMO	Modulation Schemes with 2x2 MIMO
1	5	3	1.2	QPSK,16QAM	
2	5	3	1.2	QPSK,16QAM	
3	5	2	1.8	QPSK,16QAM	
4	5	2	1.8	QPSK,16QAM	
5	5	1	3.6	QPSK,16QAM	
6	5	1	3.6	QPSK,16QAM	
7	10	1	7.3	QPSK,16QAM	
8	10	1	7.3	QPSK,16QAM	
9	15	1	10.0	QPSK,16QAM	
10	15	1	14.0	QPSK,16QAM	
11	5	2	0.9	QPSK	
12	5	1	1.8	QPSK	
13	15	1	17.6	QPSK,16QAM,64QAM	
14	15	1	21.1	QPSK,16QAM,64QAM	
15	15	1	23.4	QPSK,16QAM	QPSK,16QAM
16	15	1	28.0	QPSK,16QAM	QPSK,16QAM
17	15	1	17.6	QPSK,16QAM,64QAM	
			23.4		QPSK,16QAM
18	15	1	21.1	QPSK,16QAM,64QAM	
			28.0		QPSK,16QAM
19	15	1	35.3	QPSK,16QAM,64QAM	QPSK,16QAM,64QAM
20	15	1	42.2	QPSK,16QAM,64QAM	QPSK,16QAM,64QAM

The first terminal categories supported by mobile terminal equipment vendors belong to categories 5, 6 and 12. Terminal categories 5 and 6 are aimed for mobile handheld terminals, while category 12 is mainly aimed for PC plug-in cards with HSPA support. Terminal categories 13-20 support Evolved HSPA with MIMO and/or 64QAM.

3.5.2 EUL/HSUPA Terminal Categories

3GPP has standardized 7terminal categories for EUL/HSUPA support. Depending on number of codes, spreading factor and TTI supported the terminals allow for an uplink peak bit rate on the physical layer of up to 11.8 Mbps.

Note: The bit rates shown in plots are the RLC peak rates.

Category	Max # codes	Min spreading factor	Channel elements	Support for 2ms TTI	Layer 1 peak rate [Mbit/s]	RLC peak rate [Mbit/s]
1	1	1 X SF4	16	No	0.74	0.70
2	2	2 X SF4	32	Yes	1.46	1.38
3	2	2 X SF4	32	No	1.46	1.38
4	2	2 X SF2	64	Yes	2.92	2.75
5	2	2 X SF2	64	No	2.00	1.89
6	4	2 X SF4 + 2 X SF2	96	Yes	5.76	5.47
7	4	2 X SF4 + 2 X SF2	96	Yes	11.8	11.0

3.5.3 Recommended Terminal Combinations

The following terminal category combinations are recommended for analysis of "classic" HSPA networks and Evolved HSPA networks:

		HSDPA terminal category				
		1 - 4	5 - 12	13 - 14	15 - 18	19 - 20
EUL terminal category	1 - 3	X	X	-	-	-
	4	-	X	X	X	-
	5	X	X	X	-	-
	6	-	X	X	X	X
	7	-	X	X	X	X

HSPA networks Evolved HSPA networks

3.6 HSPA Planning Methodology

The HSPA planning function of TEMS CellPlanner is fully integrated in WCDMA analysis with Monte Carlo simulations.

The current text in this section is mainly about HSDPA. More information about EUL and Evolved HSPA will be provided in a later version of this manual.

3.6.1 HSPA User Generation

HSPA users are linked to the A-DCH radio bearer and are spread in the planned network in the same manner as the ordinary R'99 service users. You can define different A-DCH channels to reflect different combinations of A-DCHs and terminal categories within one simulation. This allows evaluation of coverage, capacity and HSPA data rates simultaneously for different terminal categories.

Because HSPA users are mapped to the A-DCH channels, existing definitions can be re-used for HSPA planning, including:

- Uniform traffic demand
- Land-use or traffic map based user generation
- Traffic spreading

3.6.2 Power Allocation for HS-SCCH and HS-DSCH

The HS-DSCH is a rate controlled downlink channel. Coverage can be provided for this channel in the entire cell coverage area. Rate control implies that users under favorable radio conditions and close to the cell are able to achieve high peak bit rates, while users at the coverage edge of the cell and under bad radio conditions are switched down in achievable data rates.

The coverage of the HS-DSCH channel is limited mainly by the coverage of the control channel for HSPA - the HS-SCCH. The HS-SCCH channel is a common channel for the cell and is handled in a similar manner as the P-CPICH channel. As all other common channels the power allocation for the HS-SCCH is done in relation to the P-CPICH. This ensures that the P-CPICH remains the main controlling channel in WCDMA. Any power change for the P-CPICH leads to relative power changes for all other common channels (including the HS-SCCH) in a cell. The power allocated to HSPA depends on how much power is required to serve the R'99 traffic. While simulating HSPA users, priority is always given to R'99 traffic. This means that the power available after all common channels and all R'99 traffic as per traffic demand definition have been served (or blocked for any overload reason) is allocated to the HS-DSCH.

This has an impact on the admission control settings for the cell. In a network with only R'99 traffic as much as 90% of the cell output power can be allocated to common channels and R'99 traffic. Using HSPA, a certain minimum power range

should be made available for the HS-DSCH to achieve acceptable peak bit rates and cell throughput on HSPA.

The power admission threshold in the HSPA enabled cells should be set to a lower value than 90%. Obviously, when deploying HSPA on an existing carrier with R'99 traffic, there is a trade off between the power required to serve R'99 traffic without introducing higher traffic blocking in the cell, and the power that can be used on the HS-DSCH channel. A general suggestion is to lower the power admission threshold for R'99 traffic to a value between 60 and 75%.

3.6.3 HSDPA Peak Data Rates and Cell Throughput

Based on the available power for the HS-DSCH a downlink C/I can be calculated for each HSPA user in a cell. This C/I value is then mapped onto system simulation results to provide a figure for the peak bit rates that can be achieved by the different terminal categories.

The mapping of C/I to peak bit rates is used to generate coverage probability plots for different peak bit rates in the planned HSPA network. An average HSPA user probably does not require the full peak bit rate all the time he is active. Consequently, it would be too pessimistic to assume that all HSPA users constantly require the peak bit rate as can be achieved based on a certain C/I value on the HS-DSCH. Instead the HSPA users are likely to require a certain average bit rate that is normally below the peak bit rate.

You can set a requested average HS-DSCH bit rate for a user on the A-DCH level. In the simulations this parameter is used for calculation of the downlink interference in HSPA enabled cells.

In a similar way the HS-DSCH cell throughput depends on the average requested downlink bit rate for HSPA users. This parameter is calculated by taking the total HSPA users and their respective average requested bit rates into account.

3.6.4 Impact of HSDPA in Existing WCDMA Networks

When enabling HSPA on the same frequency layer as already existing R'99 traffic, there is an impact on coverage, capacity and quality of this WCDMA system.

The main impact comes from the requirement that additional power needs to be allocated to the HS-SCCH, to the A-DCH(s) as well as to the HS-DSCH. Furthermore, the HS-DSCH requires sharing of cell code resources for HSPA users. These resources are taken from the same code tree as originally allocated for R'99 radio bearers.

3.6.5 Impact on Uplink Coverage and Capacity

The HS-DPCCH is mapped on the uplink onto the A-DCH. It requires a packet switched 64kbps channel to transmit the CQI measurements to the cell/RBS. This

channel is terminated in the RBS and cannot be in soft handover. As no soft handover gain applies to this channel, it needs to be transmitted with a higher power once the terminal is in a soft handover region. This and the fact that the HS-DPCCH is transmitted on a 64 kbps or up to 384 kbps uplink channel introduce a higher uplink interference in the cell. As a result, the noise rise in the cell increases. This has an impact on the uplink coverage and capacity of an HSPA-enabled cell. The expected impact is hard to quantify in general, but it depends on the users connected to a cell with an HS-DPCCH on 64 kbps and above.

To keep the uplink interference at an acceptable level, you have the option to set the total HSPA users as well as the maximum SF4-users on the HS-DPCCH admitted into a cell.

3.6.6 Impact on Downlink Coverage and Capacity

The impact of HSDPA on the downlink is twofold. Firstly, the power admission threshold for R'99 traffic should be decreased to a value that allows to achieve acceptable peak bit rates and throughput for HSDPA users. This has a direct impact on the blocking and down switching of R'99 traffic in a cell.

Secondly, the introduction of the HS-DSCH requiring all remaining cell power after that power has been allocated to common channels and the R'99 traffic has been served, leads to the fact that all HSPA-enabled cells transmit close to their maximum power limit. This has a direct impact on the perceived downlink interference in the cell. As a consequence of this the coverage of the cell for P-CPICH and the R'99 traffic channels might be degraded, with a higher blocking of R'99 users due to excessive downlink interference or downlink power limitations in the cell.

You must revise power settings for all common and dedicated channels and all HSPA channels to ensure that acceptable HSPA peak rates and cell throughput can be achieved while supporting the R'99 traffic capacity and coverage in HSPA-enabled cells.

3.6.7 Impact on Channelization Code Resources

The HS-DSCH shares orthogonal code resources with common channels and R'99 traffic channels when deployed on the same frequency layer as the existing system. Using only the primary scrambling code a cell has in total 256 channelization codes available. Since the HS-DSCH is using channelization codes with spreading factor 16, a fare amount of codes in a cell needs to be reserved for this channel.

The first system and terminal implementations for HSPA from different vendors initially only support up to 5 codes on SF16. This requires that you reserve 80 SF256 codes for the HS-DSCH.

The impact on the cell capacity is obviously that a higher blocking due to code limitations might occur for R'99 traffic in highly loaded cells. Again, the codes to be allocated to the HS-DSCH is a trade-off between cell capacity for R'99 traffic and for HSPA number of users, cell throughput and peak bit rates.

3.7 How to Integrate HSPA in a WCDMA Network Plan

The tasks below describe how to define and analyze an HSPA network plan. For information on underlying theory and preparations, see HSPA Planning Methodology on page 3-12.

1. Set up HSPA-enabled cells

   Use the HSPA parameters window in the **WCDMA RBS explorer** to set HSPA-related parameters at the cell level.

2. Define radio bearers for A-DCH

   Distribution of HSPA users in a simulated network requires A-DCH radio bearers with associated traffic demand. Define WCDMA A-DCH radio bearers and their bit rates for different terminal categories using the **System explorer**.

3. Define HSPA-capable terminals

   To generate HSPA connection rate and throughput results, you must define one or several HSPA capable terminals using the **Equipment explorer**.

4. Define traffic demand mixes with HSPA terminals and bearers

   HSPA user generation and spreading is depending on the selections made for the traffic demand mix that forms an input to the simulation. The HSPA users can be spread in the network in the following ways:

   - as uniform traffic demand
   - as a land-use based traffic demand
   - as a traffic demand based on a traffic density map

   Create a traffic demand mix using the **System explorer** to link together the HSPA-capable terminal with the corresponding A-DCH radio bearer and a defined traffic density map or uniform traffic spreading. See "Define Traffic Demand" in the *TEMS CellPlanner Common Features User's Guide* for details.

5. Run WCDMA analysis simulating HSPA

   In WCDMA analysis, set the HSPA parameters in the **WCDMA analysis** window.

   Provided that all other simulation parameters have been set correctly, you can start the simulation of HSPA users as part of WCDMA analysis. After successful simulation, WCDMA analysis generates statistics and plots for HSPA.

6. Evaluate HSPA planning results

   HSPA related plots and statistics are generated by WCDMA analysis when the following conditions are met:

   - the cells in the network are HSPA capable and enabled for the planning
   - HSPA capable terminals have been defined
   - A-DCH radio bearers have been defined
   - The traffic demand mix for which the simulation was run, containing at least one A-DCH radio bearer and a HSPA capable terminal
   - WCDMA analysis was run with HSPA enabled

4
Using MBMS in WCDMA Networks

This chapter describes TEMS CellPlanner support for MBMS.

Topics **Page**

About MBMS 4-2
MBMS System Architecture 4-2
MBMS Area Concepts 4-3
MBMS Radio Channels 4-3
Soft Combining with MBMS 4-3
MBMS on a Specific Frequency 4-4
MBMS Planning Aspects 4-5

4.1 About MBMS

MBMS enables data to be transmitted via a PTM connection – from a single source to multiple recipients. A PTM connection transmits merely one data flow per service, for example a TV program, all the way from the source to the UE. As a result the network resources are shared and an arbitrary number of UEs can receive the same MBMS data.

3GPP has specified two separate MBMS modes – multicast and broadcast. The typical difference is that in MBMS multicast the Core Network (CN) keeps track of the UEs and furthermore, that the UE join a MBMS service through a specific procedure. The MBMS implementation in WCDMA RAN P6 is based on MBMS broadcast principles and it has the following fundamental characteristics:

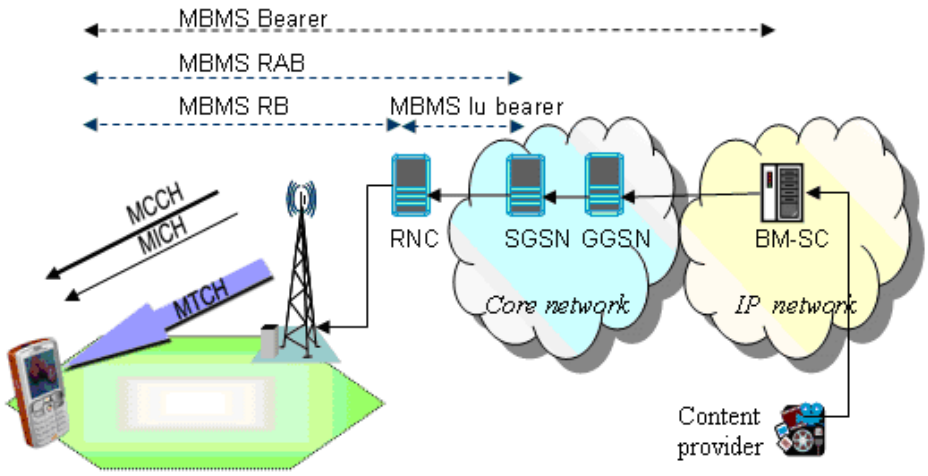
1. Network (UTRAN/CN) is unaware of receiving terminals
2. No UE counting mechanisms in RAN
3. Service is delivered to (one or more) given MBMS service areas
4. Only PTM transmission (no MBMS PTP)
5. No MBMS uplink (no reverse link for quality feedback)

To support MBMS, a UE must be MBMS capable.

4.2 MBMS System Architecture

MBMS adds a number of new capabilities to the existing nodes and adds a new entity, the Broadcast Multicast Service Centre (BM-SC) in the service layer.

Figure 4–1 MBMS system architecture overview



4.3 MBMS Area Concepts

The MBMS feature introduces the new area concept MBMS Service Area (MBMS SA). One MBMS SA contains a set of cells. One MBMS SA (same identity) can be confined to one or several RNCs. MBMS SAs may be partly or completely overlapping, that is, one cell may be connected to several MBMS SAs. The MBMS SA is configured in the RNC using OSS-RC.

A Broadcast Service Area is a union of one or several MBMS SAs.

4.4 MBMS Radio Channels

Three new radio channels types are introduced; a user data channel and two control channels. The MBMS Traffic Channel (MTCH) is the logical channel that carries the MBMS user data. The MBMS Control Channel (MCCH) broadcasts control information from the RNC to all MBMS UEs in one cell. Finally, the MBMS Notification Indicator Channel (MICH) is used to notify UEs about upcoming change in information on the MCCH. The absolute power levels of these channels are set per cell through operator controllable parameters in the RNC. The output power is static and set relative to the P-CPICH power in the cell.

The MCCH is a signaling radio bearer with transmission rate 7.6 kbps and SF=256. The MCCH uses DTX, and is therefore silent when no data needs to be transmitted and the activity factor will thus vary.

The MICH is a fixed rate physical channel with rate 30 kbps and SF=256. The activity on MICH is fixed and equal to 0.96.

The MTCH is provided in three different rates, each with a separate license key:

MTCH 64 (64.8)	kbps	SF=32
MTCH 128 (129.6)	kbps	SF=16
MTCH 256 (259.2)	kbps	SF=8

There is a restriction in the maximum number of MTCH channels per cell; no more than 10 simultaneous MBMS services are allowed in a cell regardless of the MTCH rate. The MTCH use DTX when there is no data to be transmitted. The activity factor therefore depends on the characteristics of the user service. The MTCH power is set individually for MTCH 64, MTCH 128 and MTCH 256.

4.5 Soft Combining with MBMS

An MBMS capable UE must be able to do soft combining on the physical layer and shall always attempt to combine MTCH information from up to three radio links, i.e. three cells. MBMS soft combining gives a significant gain that appear as a possibility to reduce transmitted power for the MBMS PTM traffic channels. There is a central

difference between MBMS soft combining and WCDMA soft handover functionality: while soft handover involve setting-up/tearing-down radio links, and therefore impact radio resource consumption, the MBMS soft combining only involves the UE receiving and combining information from already existing data flows.

There is no soft combining for the following cases:

- Cells in different RNCs
- Cells in different MBMS Broadcast Service Areas
- Different frequencies

4.6 MBMS on a Specific Frequency

Even if the WCDMA system has more than one frequency carrier it is possible to transmit MBMS user data on only one frequency. Other frequency carrier/carriers covering the same area need only to distribute MBMS control information. Cells will thus be given two different roles, as will be defined below. Cells of both roles must be included in the MBMS SA.

- The Preferred Layer (PL) cell: transmits on the frequency layer where the MTCH carrying the MBMS service user data is transmitted. In the PL cell MTCH is established, along with a MCCH and a MICH.
- The non-Preferred Layer (non-PL) cell: transmits on a frequency layer where only MBMS control information is transmitted. An MCCH and a MICH are transmitted. The control information on the non-PL cell "points" at the PL cell.

When a cell is connected to a MBMS SA its role (PL or non-PL) is defined. A cell can be PL cell for one MBMS service and non-PL cell for another MBMS service.

In order to assist the MBMS interested UE to find – and stay – on the PL cells of the MBMS service, two new functionality parts are specified:

- Frequency Layer Convergence (FLC): The FLC mechanism steers the UE, interested in a MBMS service, to re-select to the frequency layer on which the MBMS service is transmitted. FLC is applied to a UE in idle mode, and in connected mode on common channels, when it has selected an MBMS service and the service has started.
- Frequency Layer Dispersion (FLD): A UE that has changed frequency due to FLC will attempt to return to the previous frequency at MBMS session stop.

When UEs receive MBMS this affects their mobility between inter-frequency cells, but not between intra-frequency cells. During ongoing MBMS services the FLC and FLD mechanisms will therefore impact the traffic distribution between frequency carriers.

4.7 MBMS Planning Aspects

When planning MBMS, there are the following considerations:

Resource costs

MBMS competes with other services and features for the common WCDMA radio network resources:

Power

A static power setting is used for the MICH, MCCH and MTCH. An analytical method similar to the CCCH power setting is used.

Codes

Codes are dynamically allocated, according to spreading factor, just as for R99 channels. The code limitation sets an upper limit to how many MTCHs that can be supported.

Channel Elements (CE)

MBMS uses no CE in the uplink. For downlink MBMS have a CE ladder handling CE cost for usage of different MBMS channels. All MBMS channels, i.e. MICH, MCCH and MTCH, consume channel elements. The CE ladder for MBMS is hardware dependent.

Coverage

An uplink link budget needs to be done in order to determine the coverage criteria. The downlink link budget is needed for calculating output powers of MBMS radio channels.

Capacity

MBMS broadcast supports any number of UEs. The capacity for MBMS refers to the maximum number of MTCH channels with available cell power.

5
WCDMA Algorithms

This chapter describes the algorithms used in WCDMA analysis and other planning algorithms of TEMS CellPlanner.

Topics **Page**

Coverage and Capacity Simulations 5-2
Impact of Parameter Settings on WCDMA Analysis 5-10
Non-iterative Analysis 5-18
Neighbor List Analysis 5-18
Scrambling Code Planning 5-20
Pilot Channel Power Balancing 5-22
Automatic Cell Planning 5-26

5.1 Coverage and Capacity Simulations

In WCDMA, the coverage of a network depends on how heavily the network is loaded. WCDMA analysis consists of three different modes of operation, allowing WCDMA network planning with different levels of speed and accuracy.

WCDMA analysis modes available are:

- WCDMA non-iterative analysis based on uplink and downlink load assumptions
- WCDMA quick analysis based on look-up tables for uplink and downlink load
- WCDMA iterative analysis based on Monte Carlo simulations

5.1.1 Non-Iterative Analysis

Non-iterative analysis provides a rough coverage and capacity planning for the network based on assumed values for uplink and downlink load. A full set of uplink and downlink coverage and handover plots can be generated. Since this mode of WCDMA analysis does not evaluate individual user connections, no user-based statistics are available. Non-iterative analysis is mostly used in the initial stage of WCDMA network planning to arrive at a rough coverage estimate for all cells and WCDMA bearers.

5.1.2 WCDMA Quick Analysis

WCDMA quick analysis uses look-up tables for uplink and downlink load estimates. This mode takes the user distribution according to a traffic demand specified for the different radio bearers. WCDMA quick analysis is based on the concept of ASE (air interface speech equivalents) and is most suited to the availability of detailed site configuration data and ASE loading tables for the UTRAN system infrastructure. The output from WCDMA quick analysis is a more accurate estimate of the uplink and downlink load based on the user defined traffic demand and the actual base station configurations in the network plan.

5.1.3 Iterative WCDMA Analysis

Iterative WCDMA analysis based on Monte Carlo simulations is the most advanced analysis method. It simulates not only a random subscriber distribution based on the user defined traffic demand, but also uses advanced radio network functionality modelling for admission and congestion control in UTRAN. The iterative simulation process produces detailed plots and statistics on the network, site, cell, bearer and user level. This analysis mode is most suited for advanced and final WCDMA network planning. It is also a pre-condition to successfully run neighbor analysis, pilot power balancing and scrambling code planning.

5.1.4 Preconditions for Running Iterative Simulations in WCDMA Analysis

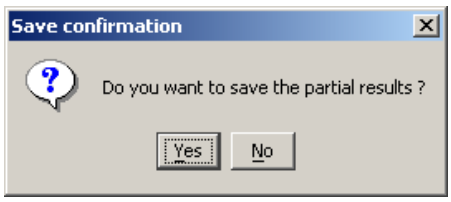
Before simulating the WCDMA radio network using the Monte Carlo simulator ensure that the following tasks are performed correctly and according to the *WCDMA User's Guide*:

- The network is created, antenna and RBS (node B) configurations are defined and the project consistency check runs successfully.
- The WCDMA radio bearers supported by the network are created, the traffic demand for each WCDMA bearer defined, and the traffic demand mix created to be used in WCDMA analysis.
- The terminal capabilities are defined so that all radio bearers to be simulated are supported by the selected terminals.
- The pathloss prediction is performed and the composite pathloss matrix created for all cells that are part of the simulation.
- The pathloss fading table used for WCDMA analysis is defined.
- If applicable, the analysis region and a possible extended region are defined for WCDMA analysis and stored as a user or project area in the **Area editor** accessed from the **Map** menu.
- The WCDMA system parameters are set correctly for WCDMA analysis to run.
- The correct set of frequency layers and calculation results is selected in the **WCDMA analysis - Calculation results** window.
- The correct parameters for the simulator are set in the **WCDMA analysis - General** window.

5.1.5 Options for Running WCDMA Analysis

Correct parameters settings are essential for running WCDMA analysis to ensure that the simulation starts with the criteria to efficiently evaluate the simulation results.

If one or more errors are discovered in the parameter settings, the simulation may be stopped at any time. The partially completed analysis results may be saved.



Depending on the changes made to the input parameters for the simulation, do the following:

- Select **Yes** to change minor settings regarding the calculation results -- the output parameter definitions.

- Select **No** to change vital input parameters to the simulations, such as changes in WCDMA network, bearer, traffic demand or area parameters.

When partial results are stored, at the re-start of the simulation, select **Continue saved analysis** in the **WCDMA analysis - General** window to use previously stored results.

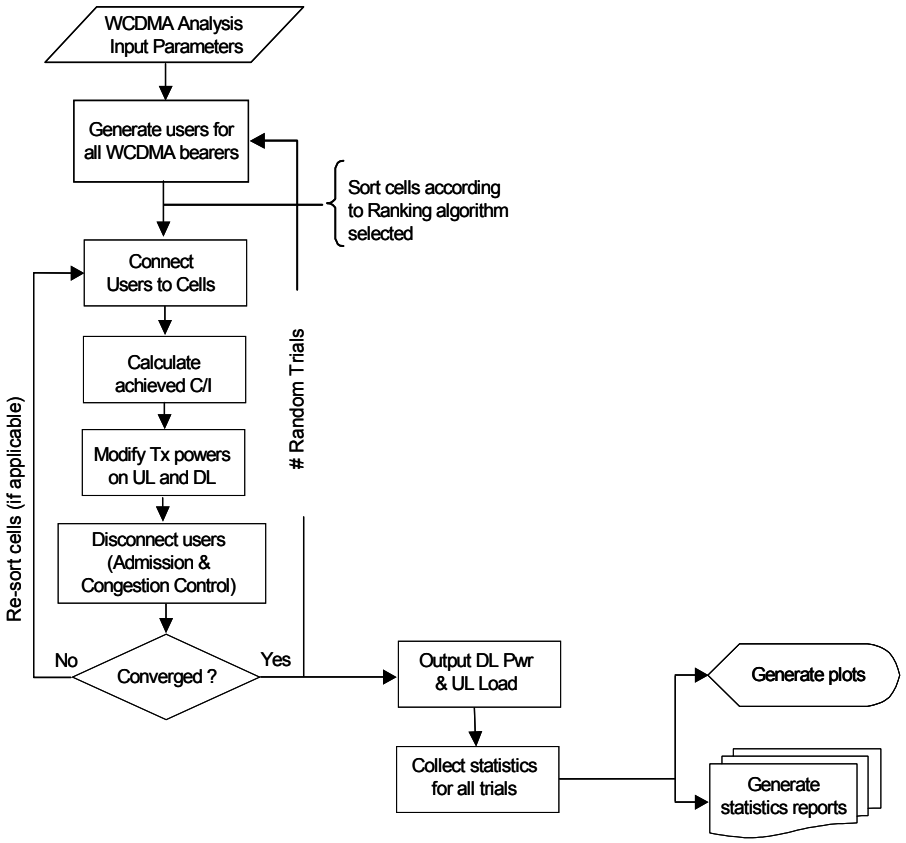
When partial results are not used, the next run of the simulator starts without considering previous results.

5.1.6 Process of Monte Carlo Simulations in WCDMA Analysis

The Monte Carlo simulator of TEMS CellPlanner is designed to reflect as closely as possible the UTRAN behavior in terms of setting up, managing, and cancelling user connections.

By simulating simultaneously all defined frequency layers for a WCDMA radio network and considering the most important UTRAN admission and congestion control algorithms, WCDMA analysis in TEMS CellPlanner becomes one of the most advanced simulators for network planning tools available on the market.

The following figure shows the main steps for the simulations:



5.1.7 Algorithms Used in Monte Carlo Simulation

During Monte Carlo analysis the following algorithms are run:

Generating Users

Depending on the traffic demand defined for each WCDMA bearer, users are generated at random locations. For the whole trial the user distribution is kept constant. If a fixed seed distribution was selected before the Monte Carlo simulator was started, the user distribution is repeated for the next trial or a completely new distribution is made at the beginning of the next trial.

The probability of occupying a certain location in the network (bin) with a specific traffic (WCDMA bearer) depends on the traffic demand in the network. Over time, the user distribution is *Poisson distributed* with a mean number of users equal to the specified traffic demand.

Traffic demand can be defined as *land-use* based or as *uniform* demand over the entire planned area. Traffic can be spread in one or more user-defined polygons. The traffic demand is always specified as number of simultaneous users per square kilometer on a specific radio bearer.

Sorting Cells According to Selected Ranking Algorithm

For each bin occupied with traffic, all cells covering the bin are ranked in priority for connection attempts. A best server list is generated for each bin. The selected ranking algorithm defines the order of the cells for which the connection attempt is made from a specific bin and WCDMA bearer.

When several frequency layers are defined, one best server ranking list exists for each frequency layer. The best server ranking list of each frequency layer gets a score value, defining the frequency layer for which the connection attempt is made first. If it fails, the frequency layer for which the connection should be tried next is used.

Connection Attempt Constraints

Starting with the highest ranked cell, each cell is checked to see if a user can connect. During the connection attempt the following constraints are tested:

- Downlink CPICH quality
- Required uplink UE TX power
- Required downlink RBS TX power

To meet the criteria, each cell must exceed the minimum threshold by at least the fading margin for the radio link to be available. The fading margins are defined in the pathloss fading tables.

Simultaneously connected cells in a bin/user are restricted by the active set size and the handover threshold. If a user cannot connect to any of the *n* best ranked cells in the best server list, the user is disconnected and the next user is processed. The parameter *n* is the maximum number of connection attempts allowed per bin/user.

When several frequency layers are defined, the next connection attempt is made on the frequency layer with the next lower score. When a connection attempt fails on all frequency layers, the user is disconnected permanently for the trial.

Calculate Achieved C/I for All Connected Users

For each mobile, the achieved C/I is calculated based on the uplink and downlink power settings and the interference known from the previous iteration. For mobiles in soft or softer handover, maximum ratio combining is performed on the downlink. For users in softer handover, maximum ratio combining is performed on the uplink, and for all users in soft handover, selection combining is performed on the uplink.

Selection combining effectively selects the link with the best C/I among the available links. With maximum ratio combining, the C/I is calculated as the sum of the C/I for the links. For cells included in the active set, maximum ratio and selection combining is performed when calculating the achieved C/I to include effects of soft or softer handover.

On the downlink non-orthogonality between the downlink channels due to multipath propagation has an impact on the downlink interference level. A non-orthogonality factor is applied for each radio link in the active set before any combination is done.

Modify Tx powers on UL and DL

After the first iteration, the number of connection attempts and active users is known. Based on the initial transmit power settings on uplink and downlink, the interference in the network can be calculated.

Over several iterations the transmit power for all cells and all user terminals is modified to match as closely as possible the achieved C/I to the target C/I. The target C/I is calculated from the user-defined uplink and downlink Eb/Io values and the spreading factors used for the respective WCDMA bearer.

In some situations and depending on the general settings for WCDMA analysis, many iterations are needed to converge the achieved C/I to the target C/I for all users and cells.

Disconnect Users - Admission and Congestion Control

The next algorithm checks capacity resources for all cells and disconnects users that would exceed the user-defined thresholds for the following parameters:

- Maximum number of UL ASE
- Maximum number of downlink ASE
- Maximum UL interference (noise rise)
- Maximum downlink power limit
- Maximum number of orthogonal spreading codes used

- Maximum number of users on spreading factor 8
- Maximum number of users on spreading factor 16
- Maximum number of users on spreading factor 32

When any of these thresholds is exceeded, users are disconnected from cells in overload based on their QoS criteria and the priority class defined for the WCDMA bearer. In general, packet switched WCDMA bearers (Interactive and Background class) are disconnected before the circuit switched WCDMA bearers (Conversational and Streaming class).

In addition to capacity limitations in cells, coverage related reasons may exist to disconnect users. For example, when a user is unable to keep the connection on uplink or downlink based on the power (and subsequent interference) changes made during the iterations.

When a WCDMA bearer supports fallback rates, the lower rate is tried for connection first. Only when the capacity allows a connection on a higher bit rate, admission and congestion control accept an increase of the WCDMA bearer bit rate.

WCDMA bearers defined as symmetrical are disconnected on both uplink and downlink simultaneously. WCDMA bearers defined as asymmetrical can be disconnected independently on uplink or downlink or both, on the link where the congestion situation occurs.

When priorities are defined for the different WCDMA bearers, those bearers with a lower priority (higher figure in the priority field) are disconnected first.

Check for Convergence

Once a possible overload situation is resolved for all cells, the system must verify if the network has achieved a stable state, in which the power changes are minimal between the iterations.

The check for convergence is based on the convergence criteria described in the following table:

Criteria	Description
UL noise rise (cell based) convergence	The trial is considered converged to a steady state when the uplink noise rise variations between two consecutive iterations is within the defined convergence limit (dB). This is the most simple convergence criteria, allowing a quick analysis of the network without the need to achieve convergence in the downlink or on a user basis. The criteria gives fast results with low accuracy, since the connection status for each user in the network is not fully verified.
UL noise rise and DL power (cell based) convergence	The trial is considered converged to a steady state when the uplink noise rise and the downlink power variations between two consecutive iterations is within the convergence limit (dB) defined by the network planner. The same value for the convergence limit is used to check uplink and downlink convergence. Using the Monte Carlo simulator allows uplink or downlink to converge at different times without negative effect on convergence of the other link. Both the uplink and downlink of all cells in the network must achieve convergence before the trial is perceived as being converged. The convergence criteria requires more iterations to complete a trial, but gives more accurate results in analysis. Both uplink and downlink have reached convergence to the specified limit. The connection status for each user in the network is not fully verified for this convergence criteria.
UL and DL C/I (user based)	This convergence criteria requires the largest number of iterations for the network to reach convergence. The network planner can safely assume that the system has converged both on the uplink and downlink for each user connection. This implies confidence in the user connection status shown in the statistics output. The convergence criteria provides the network planner with the highest available accuracy and should always be used for the final stages of the network planning process.

5.1.8 Reasons for Non-Convergence

When convergence cannot be reached, a new iteration must bring the system closer to the stable state of convergence.

Some of the reasons for not reaching convergence are:

- Too many users have been disconnected by admission and congestion control and no spare capacity exists to re-connect some users
- Switching users to a lower (fallback) bit rate gives room for new user connections in the next iteration
- The Tx power changes in the previous iteration where not sufficient to reach the convergence limit
- Some of the users have been connected to another frequency layer (if applicable) and spare capacity exists to re-connect users in one or both frequency layers

Once WCDMA analysis enters a new iteration, re-sorting cells in the best server ranking lists for all frequency layers may be required depending on the ranking method selected. Re-sorting the ranking list applies to the following ranking methods:

- Minimize terminal (UE) output power
- Best Ec/Io (for CPICH)

The reason for a new ranking of cells with these methods is that the achieved interference situation at the end of the previous iteration has an impact on the cell downlink quality (for CPICH) and the user uplink connection quality.

5.1.9 Result Plots and Statistics Generation

When convergence is reached at the end of the current iteration, the trial is considered finished. The uplink noise rise and downlink power values are stored in the result files along with the details on the user connection status for all WCDMA bearers. If there are more trials, the power values for all cells and terminals are re-set and a new trial is started by re-distributing the traffic in the network.

When the total number of specified trials is completed, the results from all individual trials are processed statistically and the following output is generated:

- Plots on frequency layer and WCDMA bearer level
- Channel dependent plots, showing dependencies between user connections and the available frequency layers in the network
- Channel independent plots not depending on the frequency layer connecting the users to the network
- Statistical reports on network, site, cell, user and WCDMA bearer level
- Statistical reports on achieved coverage and handover areas

5.2 Impact of Parameter Settings on WCDMA Analysis

Some parameters have a major impact on the speed and the result accuracy of the Monte Carlo simulations. The following paragraphs describe these parameters and their impact on the iterative WCDMA analysis based on Monte Carlo simulations.

Some parameters have an impact only when Monte Carlo is selected in the WCDMA analysis - General window.

5.2.1 General WCDMA Analysis Parameters

Number of Random Trials

This parameter defines the number of trials to run for each WCDMA analysis. The larger the number, the higher is the statistical confidence in WCDMA analysis results. In the beginning of a network planning process about 10 trials give adequate statistical confidence. For higher accuracy the number of trials should be increased, especially in a final stage of the network planning process.

Number of Iterations

This parameter defines the maximum number of iterations to be run by WCDMA analysis to reach convergence. Depending on the convergence criteria and selected convergence limit, the required number of iterations changes until convergence is reached.

For the most simple convergence criteria of uplink noise rise (cell based) approximately 5 iterations are sufficient in most cases, while for the most accurate convergence criteria of uplink and downlink C/I (user based) approximately 40 to 50 iterations are required for the system to converge.

When the maximum number of iterations is set too low for the selected convergence criteria, and WCDMA analysis does not get close to convergence, the first trial is repeated up to three times. If convergence can still not be reached, WCDMA analysis is interrupted and the network planner is asked to increase the maximum number of iterations.

Maximum Step Size

The maximum step size defines the maximum power change in dB in uplink and downlink that can be made by WCDMA analysis from one iteration to the next. The larger the step size the faster the system might converge.

The smaller the step size the more iterations are required to reach convergence.

The Monte Carlo simulator automatically adjusts the actual step size used for TX power changes. This ensures that the algorithm comes close to convergence last when the difference between the achieved and the target quality of the user

connection is large. On the other hand, at convergence the algorithm adjusts the step size to a lower value to minimize the error in setting the Tx power values.

The initial value for the maximum step size is 2 dB.

Convergence Limit

The convergence limit defines the threshold value within which WCDMA analysis is considered as converged. The smaller the convergence limit, the longer time it takes for WCDMA analysis to reach convergence, but the results are more accurate.

The value to enter for the convergence limit depends on the selected convergence criteria. For cell based convergence criteria it is suggested to set more stringent requirements of 0.2 to 0.5 dB, while for the user based convergence criteria a convergence limit of 0.8 to 1.0 dB is acceptable.

The main reason for applying more stringent requirements to the cell based convergence is that the higher convergence limit leads to a higher uncertainty in the analysis results. The higher uncertainty is not a limitation of WCDMA analysis in TEMS CellPlanner. The convergence limit is one of the steering parameters for WCDMA analysis, depending on the relation between the convergence criteria, the limits set, and the expected accuracy of the analysis results. Changing input parameters to a simulator as is used in WCDMA analysis can have a rather large impact on the accuracy of the results.

Use Fixed Seed

This parameter is used by the random number generator in the simulator for placing users in the network. One of the steering parameters for generating users is the traffic density map for the WCDMA bearers, another parameter is the actual random selection of bins for traffic allocation.

When the fixed seed option is selected, the random number generator always starts from the same starting value, leading to the same user distribution (seed) for all the consecutive trials and, consequently, to reproducible results for two or more runs of WCDMA analysis.

This option should not be used to simulate different locations for users in the network for each trial. Because the starting value for the random number generator is changed for every trial, the simulation results in different user locations for all trials.

The Value parameter shows the currently set starting value for the random number generator. Changing the value influences where the user generation function starts to distribute users in the network. It has a very minor impact on the final WCDMA analysis results.

Export to Traffic Data File

This option allows you to export statistical traffic data on a per-cell and WCDMA bearer level from WCDMA analysis to an output file, used by the Ericsson transport

network planning tool WCDMA Transporter. The file format is a tab-delimited ASCII file and adheres to the specifications for WCDMA Transporter data input.

If you are not using WCDMA Transporter, this feature is of minor importance.

Convergence Criteria

Use the radio buttons to set the desired convergence criteria. A detailed description on the use of different convergence criteria is provided in the "Process of Monte Carlo Simulations in WCDMA Analysis" as well as in the *TEMS CellPlanner WCDMA User's Guide*.

Percent of Users Converged

For the user based convergence criteria, you can set the percentage of users for which convergence is reached before the trial is considered as converged. Usually it takes approximately 20% of the analysis time to get about 80% of the users to convergence. The remaining 20% of the users require about 80% of the analysis time, due to the rather small power and interference changes made during the later phase of the analysis and as more and more users are getting converged. For maximum accuracy of WCDMA analysis this parameter is set to 100%.

Continue Saved Analysis

If you stopped WCDMA analysis during a simulation before the trials finished, you can store the partial results of your analysis. Once partial results are saved, the analysis can continue using previously made calculations and continues the analysis based on stored results. The simulation continues with the next iteration of the current trial that was stopped earlier.

Use Generated Users

This option allows re-use of the same user distribution of the last trial run in the previous simulation. In addition the user's position in latitude and longitude can be edited by pressing the Edit users... button.

The previously generated users can be re-used for only one trial. Several trials cannot be run on the previously defined user distribution.

To re-use the same user distribution for all trials select Use fixed seed.

5.2.2 Region Parameters for WCDMA Analysis

If you have pre-defined one or more analysis regions in the Area editor you can run WCDMA analysis for the area only. A precondition for WCDMA analysis in a selected region is that all cell in that region are covered by the pathloss and CPLM Analysis.

The analysis region can be extended by a certain distance. It is suggested to always use an extended region when running WCDMA analysis in a limited area. In such cases, the users are also be distributed within the extended part of the analysis region and interference contributions from these regions can be considered by WCDMA analysis. Otherwise, the analysis region is treated as an isolated area without any surrounding cells and users that would contribute to the interference in the network.

When planning within a limited analysis region make sure that the pathloss and CPLM analysis results cover both the analysis region and a possible extended region, since the information is vital input to WCDMA analysis.

The suggested extension in kilometers for the analysis region is about twice the average site-to-site distance in the analysis region. The extension ensures that the interference contributions from cells and users in the neighboring sites of the analysis region are considered.

5.2.3 Algorithm Parameters for WCDMA Analysis

Under this tab the parameters that control the load and the link specific algorithms are summarized. You can also select the ranking algorithm used for sorting the cells for connection attempts from generated users to the network.

General parameters - Effective load factor UL/DL

Short-term fading under strong multipath propagation conditions can lead to an average power increase of the transmitters in the network, since power control can no longer keep up with the fast changing fading environment. To simulate the effect, also called Tx-increase, you can increase the overall uplink and downlink loads for the network by increasing the effective load factor.

In the simulations the uplink and downlink traffic load values are scaled according to the value set for these parameters. A suggested value for simulating the strong fading is 1.1 top 1.2, a 10% to 20% load increase due to the strong multipath fading and imperfections in power control.

General parameters - Minimum DL Ec/Io for CPICH (dB)

This parameter is the minimum CPICH quality required by the mobile terminals in any position of the network to get a successful connection to the system. In other words, it is the minimum required CPICH quality for the mobile terminals to correctly detect and decode the pilot channel of any cell in the planned network.

A suggested value to set is in the range of -18 dB to -20 dB.

The parameter is used by the analysis algorithm to evaluate the user connection criteria. Only if the user position is covered by a sufficiently strong pilot signal a connection attempt can be made from that position.

CPICH coverage plots are also depending on the setting of the parameter, since they are presented as a quality margin (Ec/Io margin) relative to the minimum downlink Ec/Io for CPICH that you entered here.

General parameters - Min. pilot pollution threshold (dB)

The cells with an Ec/Io above this threshold are pilot polluter candidates. To further reduce the number of pilot polluters a relative pilot pollution threshold is also considered.

The analysis algorithm evaluates all cells, except for the cells belonging to the active set, and cells with an Ec/Io below Minimum pilot pollution threshold.

A suggested value to set is the default value -24 dB.

General parameters - Rel. pilot pollution threshold (dB)

This parameter sets a limit on how much lower the Ec/Io a cell can have relative to the Ec/Io of the best serving cell in the bin and still be considered a pilot polluter, according to the formula:

Ec/Io (pilot polluter candidate) > minimum pilot pollution threshold

AND

Ec/Io (pilot polluter candidate) > Ec/Io (best serving cell) - relative pilot pollution threshold

Example:

Minimum pilot pollution threshold = -24 dB

Relative pilot pollution threshold = 6 dB

Ec/Io of the best serving cell = -14 dB

The pilot polluter candidate is pilot polluter if its

Ec/Io > max of {-24 dB, -14 -6 dB}, that is Ec/I0 > - 20 dB

A suggested value to set is the default value 6 dB.

The found pilot polluters can be displayed in the pilot polluters count plot.

General parameters - Chip rate (kcps)

The parameter is the chip rate of the (W)CDMA system that you want to analyze. The chip rate defines the noise floor level in the receivers of the network. The larger the chip rate and the bandwidth of the radio system, the more noise is picked up and the higher becomes the background noise floor level.

The standard chip rate for a WCDMA system according to 3GPP is 3840 kcps or 3.84 Mcps. If you have a standard WCDMA system this parameter should not be changed.

WCDMA analysis can also perform Monte Carlo simulations for (W)CDMA systems with chip rates other than the standard 3GPP chip rate.

Ranking Algorithm Selection

The choice of ranking algorithm defines the order of the cells in which the connection attempt is made from a specific bin on a specific WCDMA bearer.

For all ranking algorithms any effects of soft or softer handover is considered.

The ranking algorithm **Lowest pathloss** ranks those cells first for the connection attempts that have the lowest pathloss to a specific position (bin) in the network. The ranking method is purely based on the predicted pathloss values and does not consider the interference situation in that bin or for the respective cells.

The ranking algorithm **Minimum mobile output power** ranks those cells first for the connection attempts that have the best uplink channel quality, leading to the lowest mobile output power once the mobile is active and connected to the network. The ranking method uses the uplink interference situation for all cells when ranking the cells.

The ranking algorithm **Best Ec/Io** ranks those cells first for the connection attempts that have the best downlink CPICH quality for a particular position (bin) in the network. The ranking method uses the downlink interference situation for all cells. **Since the mobile terminals perform measurements for Active Set update in a soft or softer handover situation, this ranking method is suggested as a standard.**

The ranking algorithm **Strongest signal** ranks those cells first for the connection attempts that have the strongest downlink CPICH signal for a particular position (bin) in the network. The ranking method is mainly based on the CPICH output power settings for the cells and the pathloss between the cells and a particular bin. It does not consider any downlink interference when ranking the cells.

Handover Parameter Settings

The handover parameter settings control the connection of users to cells.

The parameter **Active set size** defines the maximum number of cells a mobile terminal could be connected to simultaneously in any position in the network. The pre-condition for being part in the active set is that the quality difference of all cells in the ranking list is within the limits as defined by the Handover threshold. The initial setting is 3.

The parameter **Number of connection attempts** specifies the maximum number of cells that a mobile terminal can try for a connection to the network. If the terminal does not succeed in getting a connection to the network within the specified limit it is disconnected permanently for the duration of that trial. In a next trial, a new series of connection attempts can be made. The initial setting is 5. The more connection attempts allowed the longer WCDMA analysis takes to converge.

The parameter **Handover threshold (dB)** specifies the limits, within which cells are considered to be part of the active set. The suggested value corresponds to the Add-

threshold for the soft and softer handover connection, 3 dB. A larger value presents a higher risk that cells with a rather weak pilot signal quality are allowed into a handover connection. Increasing the handover threshold to values much higher than the suggested value implies a risk for handover failures in the real network.

Fading Margin Table

The drop-down menu lists the pathloss fading table specified for the analysis region or the whole network.

5.2.4 Traffic Demand Parameters for WCDMA Analysis

Traffic demand parameters include the traffic demand mix used to run WCDMA analysis. The traffic demand mix must be pre-defined in the System explorer before WCDMA analysis can be run.

The field Associated traffic demand entries provides the details of the WCDMA traffic demand selected. Most entries in the window cannot be changed. To change the traffic demand parameters use the System Explorer - Traffic demand window.

The only parameter that can be changed is the bit rate for which the plot generation is done. The selection becomes available if there are WCDMA bearers with multiple rate sets defined in the WCDMA traffic demand mix. For these bearers you can base plot generation on any of the rate sets defined for the bearers. When you do not select any of the rate sets in the bit rate selection, the plots are based on all available rate sets. You can see the effect of channel rate switching in, for instance, the coverage plots.

5.2.5 Calculation Result Parameters for WCDMA Analysis

The parameters on the Calculation results window define the plots and the way they are generated from WCDMA analysis.

Plot Selection

In this field you can select the plots generated by WCDMA analysis. Selecting all plots means that a complete set of plots based on the selected coverage options for all selected frequency layers are generated and stored in the results directory of the project file.

De-selecting some of the plots not required for later evaluation speeds up the plot generation process.

To analyze a plot that was selected in the previous WCDMA analysis run, you have to re-run WCDMA analysis with the correct settings for the plot selection.

DL Traffic Channel Coverage Options

The traffic channel coverage options select the conditions under which the downlink traffic channel coverage plot is generated.

Selecting Use service DL power means that the maximum downlink power as defined for the respective WCDMA bearer is used to generate the downlink coverage plots. This is the suggested option.

Selecting Use average cell DL power means that the downlink coverage plot generation is based on the average downlink power of the respective cells. The average cell downlink power is calculated from all trials of the simulation.

Selecting Use percentile cell DL power means that the user-defined percentile of the cell downlink power (as defined under the Algorithm parameters tab) is used for generating the downlink coverage plots rather than the average value. With this option, the downlink power for plot generation corresponds to the value of all cells that achieved "percentile" during the simulation.

UL Traffic Channel Coverage Options

Traffic channel coverage conditions select the conditions under which the uplink traffic channel coverage plot is generated.

Selecting Use average cell interference means that the average interference level of the cells over all trials is used to generate the uplink coverage plot. This setting is the suggested option.

Selecting use percentile cell interference means that the user-defined percentile of cell uplink interference (as defined under the Algorithm parameters tab) is used for generating uplink coverage plots rather than the average value. With this option the uplink interference used for plot generation corresponds to the value "percentile" % experienced by all cells during the simulation.

Frequency Selection Options

You select the frequency layers for which the plots are generated. WCDMA analysis always considers all available frequency layers for the connection attempts to emulate how a WCDMA system would perform user connection.

The WCDMA statistics output file contains information on all available frequency layers.

The frequency selection done in this field does not have any impact on frequency selection by WCDMA analysis, but only on plot generation.

De-selecting a frequency layer means that the plot generation disregards the frequency layer. To analyze a frequency layer that was not selected in the plot generation of the previous WCDMA analysis run you have to re-run WCDMA analysis with the proper settings for the frequency layer selection.

5.3 Non-iterative Analysis

Noniterative analysis is performed for each WCDMA bearer and across all bins in the analysis region. The process is carried out as follows:

1. The target C/I is set for both the downlink and the uplink for the WCDMA bearers in the traffic demand mix and based on the WCDMA bearer property settings.
2. For each bin in the analysis region, the algorithm computes the following parameters:
   - Pilot channel downlink EIRP margin
   - Uplink transmission power
   - Downlink transmission power
   - Downlink traffic channel coverage
   - Uplink traffic channel coverage
   - Best server coverage

Since the non-iterative analysis does not involve any convergence towards a certain downlink power or uplink interference per cell, it is based on the respective values entered in the UTRAN cell analysis parameters accessed from the WCDMA RBS explorer.

The non-iterative analysis uses the same basic algorithms for generating the output plots as WCDMA analysis, based on Monte Carlo simulations. Consequently, the same suggested parameter settings and limitations described for the iterative WCDMA analysis apply also here.

Non-iterative analysis does not produce any statistical reports, nor are discrete subscriber plots available from this mode of WCDMA analysis

5.4 Neighbor List Analysis

The automated neighbor list generation uses network planning requirements by providing the following features:

- Identifies neighbors, generates a neighbor list, and displays non-neighbors for a new system
- Stores and updates the neighbor relations
- Allows editing the resulting neighbor list
- Allows export of the neighbor list

5.4.1 Inputs to the Algorithm

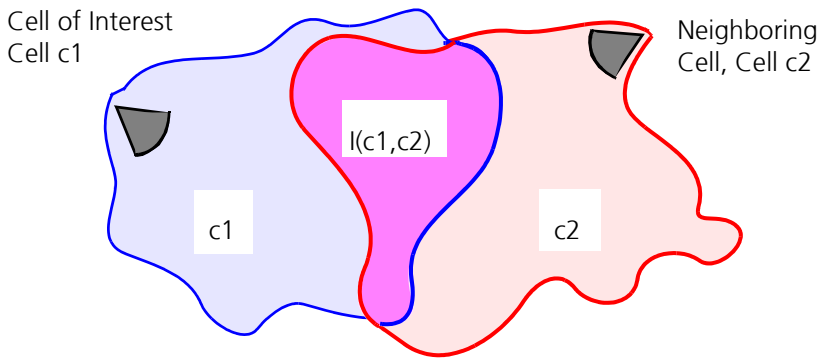
The algorithm uses the following input values:

- Percentage of traffic channel coverage overlap for each frequency layer. The planner must provide the required overlap percentage for any two cells to consider them as neighbors.
- Neighbor list from the previous run of the algorithm. The algorithm displays the previously stored neighbors for each cell so the network planner can compare results between two runs of the algorithm.

5.4.2 Region of Overlap

A *region of overlap* is defined for pairs of cells. In the region, every bin has one or more contributing cells, one of which is a serving cell. The first cell in the connection list is the serving cell for that bin. A region of overlap is created between the serving cells and the contributing cells.

The following illustration shows cells c1 and c2, where the region of overlap is the intersection I(c1, c2).



5.4.3 Algorithm Output

The algorithm outputs the following results:

- The list of neighbors and non-neighbors for each cell.
- The percentage of overlap between neighboring cells.
- The pilot values for the 10th, 50th, and 90th percentile position for each neighbor relation.

- The status of the operation, possibly one of the following:

Status	Description of the Relationship
In DB only	In the database only (from previous analysis).
Calculated	Found during the analysis.
In Both	Found in the database and also calculated.

5.4.4 Algorithm for Automated Neighbor List Generation

The automated neighbor list generation uses the following algorithm:

1. The serving cells for each bin are identified by using the output from WCDMA analysis. For all the serving cells, potential neighbors are identified based on the active and candidate cells present in each bin, where the cell under consideration is the best serving cell.
2. For all serving cells and the potential neighbors thus identified, the percentage of coverage overlap region is computed. The percentage of overlap is computed as the percentage of bins served by the serving sector also covered by the neighboring cells, as expressed in the following formula:

   ```
   [numoverlapbins(nbr)/totalnumbins(serv_cell)]
   ```

3. For each serving cell, the percentage overlap with its neighbor is compared against the planning input percentage overlap. All neighbors present in the bins in excess of the permissible extent set by the subscriber as percentage overlap are classified as neighbors.
4. The other relations created are categorized as non-neighbors, for which the number of bins served (as a percentage) is less than the defined constraint.

5.5 Scrambling Code Planning

Scrambling codes are pseudo-random noise (PN) sequences, also called Gold sequences. The PN sequences used for scrambling codes are selected from a large number of theoretically 218-1 available sequences. The selection criteria are based on the best cross- and auto-correlation properties between the codes so they may be derived with minimal risk for mutual interference. The properties consider both in-sync and out-of-sync cases.

Any two scrambling codes can be clearly distinguished in the de-correlator of the mobile terminal receiver without the need of tight synchronization between the different scrambling codes. Synchronization between different cells is not required in WCDMA, making deployment of a mobile system based on WCDMA much easier than for IS-95 or cdma2000.

Scrambling code planning assigns scrambling codes to cells so that no ambiguity exists in identifying the pilot signal at any bin in the coverage area.

Two kinds of ambiguities can occur:

- Scrambling code ambiguity linked to pilot strength

  If two cells have the same scrambling code and they are both visible at a bin, the ambiguity is called *pilot conflict*.

- Scrambling code ambiguity linked to the neighbor list merging

  The process of merging neighbor lists in a WCDMA system can cause ambiguities. When a mobile is in handover, it merges the neighbor lists provided by the cells with which it is in handover. Neighbor lists contain scrambling codes rather than cell IDs. A mobile station can recognize a cell only through its scrambling code. An ambiguity can appear if two different cells with the same scrambling code appear in two different neighbor lists. If the neighbor lists of two cells contain a scrambling code `sc1`, then `sc1` should imply the same cell. The problem appears only when scrambling codes have to be reused in the network.

5.5.1 Inputs of the Algorithm

Mandatory parameters are required for running automated scrambling code planning. Optional parameters enable the extension of an existing network and reserving scrambling codes for future evolution.

Mandatory Parameters

- E_C/I_O values from each cell in each bin. The values come from the E_C/I_O datasets output as plots from WCDMA analysis.
- The Minimum S/I threshold for interference tolerance specified by the user. The default value is 24 dB.

  If a mobile station located at a certain point receives correlated signals from two cells, this is not considered a source of ambiguity for the subscriber if the difference between the two E_C/I_O values received exceeds the minimum S/I threshold. In that case, the mobile station only "sees" the strongest signal.

- The Minimum E_C/I_O threshold specified by the user. Default value: -18 dB.

  In a bin, if E_C/I_O values received from cell1 and cell 2 are less than the Minimum E_C/I_O threshold, then those two pilots are not considered as a potential source of ambiguity for the mobile.

- The neighbor list for each cell in the system. For the algorithm, the neighbor list must be specified in terms of cell ID. The user can specify the list, or it can be obtained by using the neighbor list planning function of TEMS CellPlanner.

Optional Parameters

- The list of cells with pre-defined scrambling codes
- A percentage of scrambling codes reserved for future use

5.5.2 Algorithm for Automated Scrambling Code Planning

The automated scrambling code planning uses the following algorithm.

1. The set of available codes for a system is identified. The inputs regarding the reserved percentage of codes and pre-fixed codes, if any, are also identified.
2. For each considered cell, the algorithm identifies the potentially conflicting cells with which the cell under consideration may not share the scrambling code.
   - The conflicting cells may result from the cells being neighbors or in the handover area (neighbor constraint)
   - A cell is said to have pilot conflict with another if the difference between those two received E_c/I_o values is small enough to imply pilot ambiguity and the pilot strength of the two cells is greater than the Minimum E_c/I_o threshold (pilot constraint).
3. For each cell, a set of all the potential codes is considered. From the list of available codes, the algorithm eliminates those that may already be assigned to any of the conflicting cells. Those codes are derived from either pilot constraint or neighbor constraint, from which those that do not meet the neighbor list constraint are removed.

5.5.3 Output

The output of the algorithm is a list of cells with an associated scrambling code for each cell, where the planning was completed and successful. The scrambling code for each cell is stored under the cell-specific parameters. To view these parameters, select WCDMA RBS↗Cell↗Analysis.

5.6 Pilot Channel Power Balancing

When calculating CPICH coverage based upon a fixed power value, there is a possibility of getting areas where there is a high CPICH Ec/No margin even at the edge of the service coverage area. In such cases there is a high risk for pilot pollution since the traffic channel coverage cannot keep up with the pilot channel coverage. The power balancing function allows the network planner to balance the CPICH power towards a minimum margin for the Ec/No that is desired at the coverage boundary of the best serving cell.

5.6.1 Preconditions for Running Pilot Power Balancing

The precondition for running CPICH power balancing is that WCDMA plots have been generated, producing at least a CPICH coverage plot (as Ec/Io margin) and a Best Server Coverage plot for a selected WCDMA bearer. It is suggested to run pilot

power balancing against the WCDMA bearer with the best (largest) resulting coverage. In many cases this is the speech bearer or other low bit rate bearers.

5.6.2 Calculations for Balancing

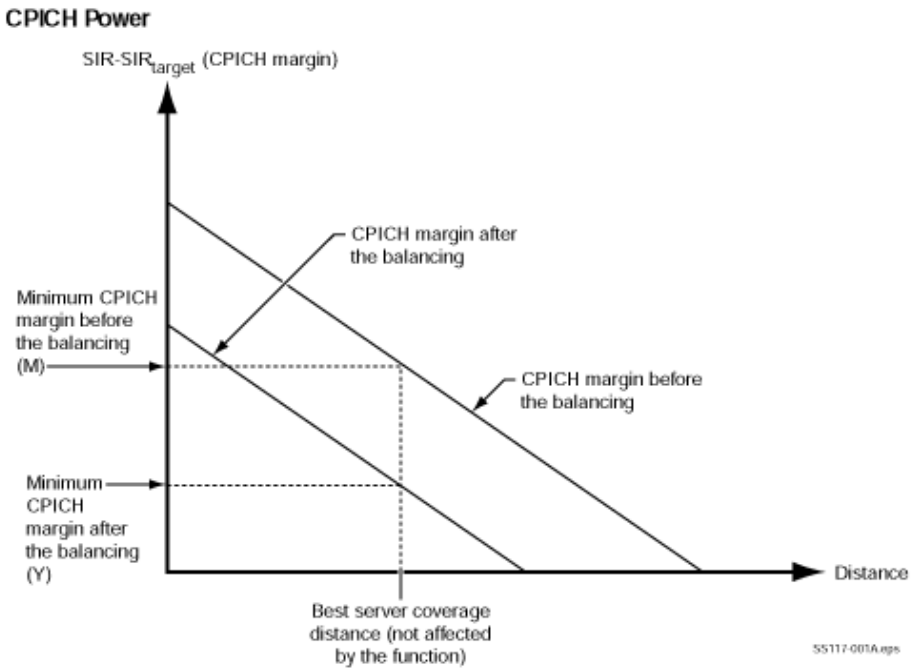
The CPICH power balancing algorithm calculates the difference (M) between the achieved Ec/No margin and the Ec/No target of the best serving cell at the cell coverage border and defines how much the pilot power of the cell is reduced to meet the margin that you defined for the cell's coverage border.

This margin (Y) is called "threshold" in the user interface. It is the minimum margin hat you want the achieved Ec/No to be better than the Ec/No target as defined in the "Algorithm parameter" section of WCDMA analysis.

You can run the algorithm on an individual basis for each cell, then the power settings are changed independently for each cell based on the minimum difference of Ec/No target and achieved Ec/No.

If you run the algorithm globally by selection the option **Analyze globally**, the power change is calculated depending on the CPICH coverage of the "weakest cell" in a group of cells in the network. The "weakest cell" is the cell that has the lowest Ec/No margin within its best server coverage area in the network.

The following figure shows the CPICH margin before and after power balancing is performed:



The calculations for the new CPICH margin are done as per following formula:

If (M - Y) > 0 then

new CPICH power = old CPICH power - (M - Y)

Since the algorithm calculates the difference between the achieved Ec/No and the target Ec/No only in the best server coverage area for the selected WCDMA bearer, it actually considers the traffic channel coverage.

Example for Calculations

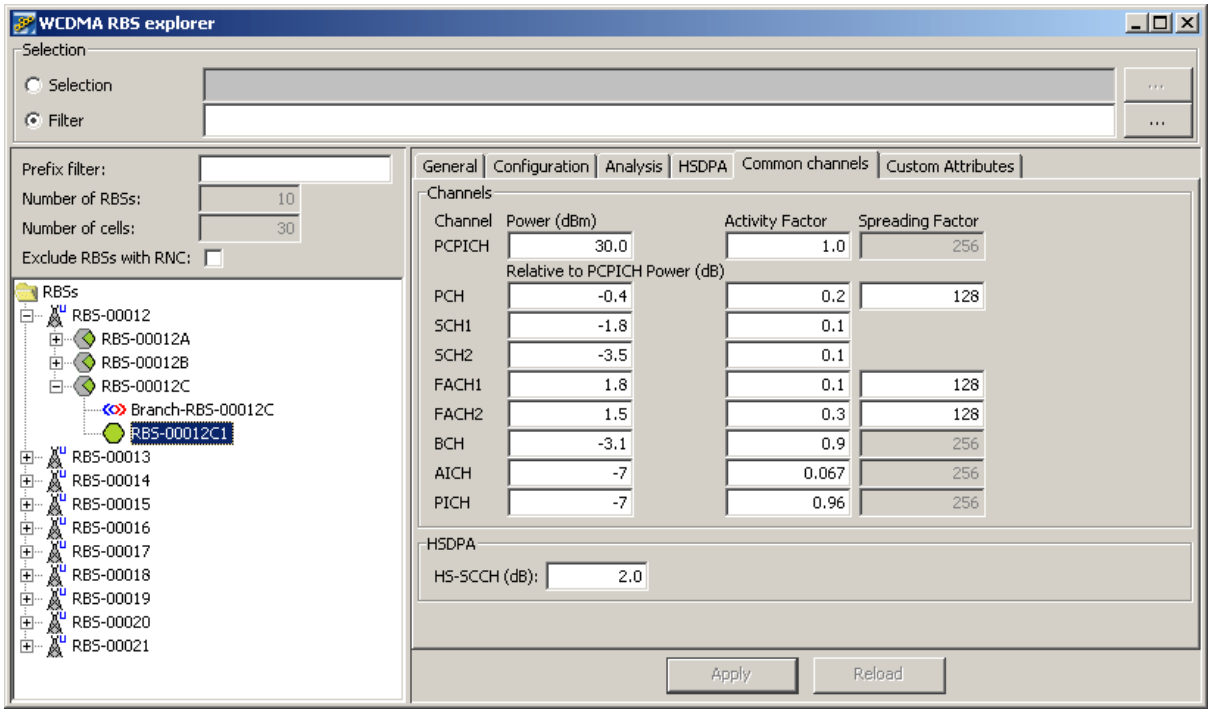
The maximum margin on the CPICH coverage in terms of Ec/No at the coverage edge of the best serving cell you would like to allow is 2 dB, but in some cells the margin is actually up to 5 dB, then for these cells the margin needs to be reduced with up to 3 dB. For each cell (individually or in a group of cells) the pilot power value is balanced so that the margin specified is achieved.

Cells with Too Weak Pilot Channel Coverage

For some cells the CPICH margin before pilot power balancing might be already below the new target value (Y) you defined for balancing. The algorithm detects such case and no pilot power changes are done for those cells. In the user interface you see a list of cells for which pilot power balancing could not be performed since their CPICH margin was already before the balancing below the value (Y) you specified.

5.6.3 Output

After pilot power balancing is performed, the algorithm changes the CPICH power setting on a per-cell level in the **UTRAN cell - Common channels** window:



Since the power settings for all other common channels have a relation to the CPICH, the power settings for all common channels are updated by the Pilot Power Balancing function.

You have to re-run WCDMA analysis to see the effect of changes in common channel power setting on the coverage and capacity of your network plan.

5.7 Automatic Cell Planning

The fundamental problem of automatic cell planning is that the number of candidate network configurations is enormous. Furthermore, the evaluation of a single network configuration takes a long time, as it requires pathloss, CPLM, and WCDMA analysis to be performed. Ideally, the ACP should ensure that the change candidates are good enough before spending time on evaluating them. However, this is not possible, as the evaluation must be carried out to find the gain of the changes, thus we end up in circular reasoning.

To resolve this dilemma, the ACP continuously analyzes the geographical distribution of problematic areas in the network, such as areas with heavy interference, to decide where the improvement efforts should be focused. When considering the candidate changes, the ACP uses two analysis algorithms:

1. The *precise analysis*, based on the standard TEMS CellPlanner analysis algorithms (pathloss, WCDMA analysis). This algorithm is used as a checkpoint to ensure that the ACP and other TEMS CellPlanner algorithms have the same view of the current radio situation as the network evolves during the ACP optimization.
2. The r*ough analysis* is used to quickly find promising changes. This is a less accurate, but faster, algorithm compared to the precise analysis. All changes proposed by the rough analysis are verified with the precise analysis before being accepted.

Note that the same parameter can be changed more than once during the ACP optimization, since a value that is optimal at an early stage may later become non optimal due to other changes in surrounding cells. Therefore, the number of changes in the final rollout plan is often lower than the number of accepted changes in the optimization progress window. For example, if the tilt of a specific cell is first changed from two to four degrees, and later from four to six degrees, it counts as two accepted changes even though it will be a single change in the final rollout plan.

Index

Numerics

16QAM 3-2
3GPP 2-7, 2-25, 3-3
64QAM 3-2

A

achieved C/I 5-6
ACP 5-26
active set 2-38, 2-42, 5-5–5-6, 5-15
  size 5-15
activity factor 2-10–2-12, 2-19
  user 2-19
admission control 2-8, 2-20, 2-24, 2-30, 5-2, 5-6–5-7, 5-9
  algorithms 2-32, 5-4
    downlink power 2-31
  maximum code tree use 2-30
    all bearers 2-30
  parameters 2-30
  simulating 2-30
air interface capacity
  WCDMA 2-24
Air Interface Speech Equivalents. See ASE
antenna 2-24, 5-3
  combiner 2-25
  configuration 2-31
  equipment 2-25
  feeder 2-25
  gain 2-21
  height 2-21
  radiation patterns on downlink 2-24
  radiation patterns on uplink 2-24
areas
  code 2-52
    assigned to cells 2-51
  codes 2-52
  configuration 2-51
  interdependencies 2-53
  mobility 2-52
ASE 2-12–2-13, 2-20, 2-24, 2-30–2-31, 5-2
  limits on uplink 2-31
  maximum downlink air interface load 2-30
  maximum on downlink 2-31, 5-6
  maximum on uplink 2-31, 5-6
  maximum uplink air interface load 2-30
  requirements 2-20
automatic cell planning 5-26
average bit rate 2-8–2-11, 2-19
average power mode 2-11–2-12, 2-19

B

base station 2-24, 2-28–2-29, 2-31
  capacity 2-24–2-25
  configuration 2-31, 5-2
  hardware capacity 2-25
  mini-cell 2-6
  pooling channel elements 2-27
  pooling gain 2-28
  pooling resources 2-27
  RAKE receiver 2-29, 2-42
  templates 2-6
  types 2-6
  WCDMA 2-24
baseband processing 2-25, 2-28
  downlink 2-26
  uplink 2-27
bearer 2-4, 2-18, 2-50
  circuit switched 2-8–2-9, 2-12, 2-19, 2-25
  connection priority 2-19
  data rates 2-5
  packet switched 2-9–2-13, 2-19, 2-25
    priority 2-19
  priority class 2-19
  properties 2-7, 2-9, 2-17–2-18
  supported 2-21
  types 2-7, 2-19
bearer data rates 2-5
best C/I 5-6
best server list 5-5
best server ranking 5-5

bit error 2-26–2-27
correction 2-26
detection 2-26
rate
residual 2-7
bit rate 2-8–2-10, 2-12, 2-14, 2-17, 2-19–2-20, 2-24–2-27, 2-30–2-32, 3-10, 5-7, 5-16, 5-23
average 2-8–2-11, 2-19
current 2-8
downlink 2-31
fallback 2-20, 5-9
guaranteed 2-7–2-8
maximum 2-7
multiple 2-33
peak 2-8–2-10, 2-19–2-20
guaranteed 2-8
switching 2-9
blocking 3-14
body loss 2-14
building penetration loss 2-14

C

C/I 5-6
achieved 5-6
downlink 5-8
uplink 5-8
capacity 3-14
downlink 3-14
uplink 3-14
capacity requirements 2-25
car penetration loss 2-15
cdma2000 5-20
cell-based positioning 2-51
channel
bit rate 2-17
coding 2-26
common channels 2-31
dedicated channels 2-31
dedicated data 2-26
dedicated signaling 2-26
peak rate 2-8
properties 2-34
channel element 2-19, 2-25–2-26, 2-28–2-29
calculating required resources 2-33
common hardware resources 2-25
definition 2-25
Ericsson definition 2-25–2-26
mapping definition 2-25
number required 2-29
pooling 2-27–2-28
over frequency layers 2-28
over sectors 2-28
speech 2-25
uplink 2-27
channel models 2-16–2-17
channelization codes 2-20, 2-31, 2-44
downlink 2-30, 2-32
maximum allocated
downlink 2-32
circuit switched applications 2-9
circuit switched bearer 2-7–2-9, 2-11–2-12, 2-19, 2-32, 5-7
priority 2-19
QoS 2-20
conversational 2-7, 2-12
streaming 2-7, 2-12
speech users 2-8
video streaming 2-8
circuit switched network 2-53
circuit switched service 2-9
combining method 2-42
dependencies 2-42
handover gain 2-42
maximum ratio combining 2-38, 2-42–2-43, 5-6
selection combining 2-38, 2-42, 5-6
composite pathloss matrix 5-3, 5-12–5-13
congestion control 2-8, 2-20, 2-24, 2-30, 5-2, 5-6–5-7, 5-9
algorithms 2-20, 2-32, 5-4
priority 2-18
connection priority 2-18–2-19
bearer 2-19
constraint
connection attempt 5-5
downlink CPICH quality 5-5
neighbor 5-22
neighbor list 5-20
pilot 5-22
required downlink RBS TX power 5-5
required uplink UE TX power 5-5
convergence 5-8–5-10, 5-12, 5-18
cell based 5-11
check for 5-8
criteria 5-8, 5-10–5-12
cell based 5-8, 5-10–5-11
user based 5-8, 5-10–5-12

downlink 5-8
limit 5-8–5-11
defined 5-8
not reaching 5-9
uplink 5-8
co-planning networks 2-3
core network 2-51, 2-53
coverage
downlink 3-14
uplink 3-14
coverage planning 2-17, 2-34
CPICH 2-49–2-50, 5-13, 5-24
best Ec/Io 5-9
coverage 5-22–5-24
coverage plots 5-14, 5-22
downlink Ec/Io 5-14
Ec/No margin 5-22
margin 5-23–5-24
minimum quality on downlink 5-13
output power 5-15
power 5-22
power balancing 5-22
algorithm 5-23
power setting 5-25
quality 5-13
downlink 5-5, 5-9, 5-15
relation to common channels 5-25
strongest downlink signal 5-15
CRC
evaluation 2-27
generator 2-26
handling 2-26
current bit rate 2-8

D

delay 2-9
data channel 2-9
packet switched bearer 2-9
transfer 2-7
down switching 3-14
downlink
air interface load 2-31
ASE requirements 2-20
baseband processing algorithms 2-26
baseband signal processing 2-27
bit error correction 2-26
bit error detection 2-26
bit rate 2-9, 2-20
calculating load 2-32
capacity 2-38
channel elements required 2-29
channelization codes 2-32
channels
Interactive and Background 2-20
convergence 5-8
coverage 2-38, 5-2
coverage plots 2-37
fading 2-37
fading margin 2-38
initial transmit power 5-6
interference 2-12
interference level 5-6
interleaving 2-26
load 5-2
loss 2-21
maximum ratio combining 2-42
non-orthogonality 5-6
orthogonal channelization code tree
resource 2-31
packet switched connection 2-10
peak bit rate requirements 2-20
power 2-11, 2-14, 2-20
algorithm 2-31
maximum allocated 2-31
maximum downlink load 2-30
settings 5-6
total for cell 2-31
RBS TX power 5-5
signal gain 2-42
soft and softer handover 2-42
soft handover combining 2-38
soft handover gain 2-38
soft or softer handover combining 2-42
spreading 2-26
symmetry rate 2-20
user activity factor 2-19
WCDMA analysis
non-iterative 5-2
WCDMA quick analysis 5-2
drive test 2-34
data
comparing to planned network 2-49

E

Eb/Io 2-5, 2-16–2-17
values 2-17
Ec/Io 5-21–5-22
best 5-15

margin 5-22
minimum threshold 5-21–5-22
Enhanced Uplink 3-2
EUL 3-2
terminal categories 3-11
Evolved HSPA 3-2

F

fading margin 2-14, 2-34, 2-36–2-40, 5-5
dependencies 2-37
impact on soft handover 2-38
log-normal 2-14, 2-39
pathloss fading table 2-39
table 5-16
WCDMA analysis
iterative 2-37, 2-40
non-iterative 2-36, 2-40

G

Gold sequences 5-20
guarantee margin 2-5
guaranteed bit rate 2-7–2-8
peak 2-8

H

handover 2-32
gain 2-36
neighbor list
merging 5-21
parameter settings 5-15
soft 2-36
softer 2-36
soft-softer 2-41
handover gain 2-36–2-37, 2-39–2-43
soft 2-38, 2-41–2-42
uplink 2-38
terminals on uplink 2-42
High Speed Downlink Packet Access 3-2
High Speed Uplink Packet Access 3-2
HSDPA 3-2, 3-5, 3-7–3-8
3GPP Specifications 3-3
A-DCH channels 3-12
channel structure 3-5
fast link adaptation 3-6, 3-8
hybrid ARQ 3-6
integration 3-15
Monte Carlo simulation 3-12
multiple H-ARQ 3-7
radio channel quality 3-7
short transmit time interval (TTI) 3-6
soft-combining packets 3-6
terminal categories 3-10
transmission 3-8
HS-DSCH 3-2
HSPA 3-2
bit rates 3-2
planning 3-12
terminology 3-4
HSPA Evolution 3-2
HSPA+ 3-2
HSUPA 3-2

I

idle mode 2-51
interference 3-14
downlink 3-14
interleaving 2-26
removing 2-27
IS-95 5-20
iterative WCDMA analysis 2-36

L

LAC 2-52
link budget calculation 2-17
link budget calculations 2-34
location area 2-2, 2-52–2-53
code 2-52
log-normal fading margin 2-34
simulated 2-34
long-term fading 2-34
losses
body 2-14
building penetration 2-14
car penetration 2-15

M

macro-cell 2-6
macro-cell base station 2-14
maximum ratio combining 2-38, 2-42–2-43, 5-6
micro-cell 2-6
MIMO 3-2, 3-10
mobile terminal
localization 2-52
location 2-52

mobility
areas 2-52
Monte Carlo
analysis 2-2
simulation 2-2
simulator 2-2, 2-16
Monte Carlo simulation 2-7, 2-23, 2-36–2-37, 2-40, 5-2–5-5, 5-8, 5-10, 5-12, 5-15, 5-18
multipath propagation 5-6, 5-13
multi-service network 2-17

N

neighbor cells
percentage of overlap 5-19
neighbor constraint 5-22
neighbor list 5-2, 5-18–5-19, 5-21
analysis 5-18
constraint 5-22
generating 5-18, 5-20
neighbor list merging 5-21
scrambling code vs. sector ID 5-21
neighbor relation
pilot values 5-19
network
capacity 2-2
coverage
quick estimate 2-2
network dimensioning applications 2-34
Node B 2-25
noise rise
maximum uplink limit 2-30
uplink 5-8, 5-10
non-iterative analysis 2-40, 5-2, 5-18
fading margins 2-40
non-iterative WCDMA analysis 2-35

O

orthogonal channelization codes 2-44
orthogonal code resources 3-14
orthogonal codes 2-32
orthogonal scrambling codes 2-45
output power 2-6
base station 2-6
mobile terminals 2-6

P

packet
queuing 2-9
variable size 2-10
packet switched applications 2-9
packet switched bearer 2-7, 2-9–2-13, 2-18–2-19, 2-32–2-33
capacity requirements 2-25
fallback rates 2-32
priority 2-19
QoS
background 2-7, 2-12, 2-20
interactive 2-7, 2-12, 2-20
traffic density 2-13
packet switched connection 2-19
variable packet size 2-10
packet switched users 2-10
pathloss 2-14
pathloss fading table 2-37–2-38, 5-3, 5-5, 5-16
pathloss prediction 2-14, 2-34, 2-39–2-40, 5-3, 5-12–5-13, 5-15
peak bit rate 2-8–2-10, 2-19–2-20
guaranteed 2-8
peak power mode 2-11–2-12, 2-19
peak rate 3-10
pilot 5-19, 5-21, 5-23–5-24
ambiguity 5-22
channel 5-13, 5-18
conflict 5-22
avoiding with scrambling code planning 5-21
constraint 5-22
coverage 2-49
identifying 5-20
pollution 2-49, 5-22
power 5-24
power balancing 5-2, 5-22, 5-24–5-25
signal 5-13, 5-16, 5-20
strength 5-21
strength 5-22
planning
HSPA 3-12
polygons 2-51
positioning
cell-based 2-51
mobile terminals 2-51
power
maximum allocated downlink 2-31
maximum downlink load 2-30
output 2-6
settings 2-49

power balancing
pilot 5-2
power mode 2-12, 2-19
average 2-11–2-12, 2-19
for bearer 2-19
peak 2-11–2-12, 2-19
propagation loss 2-14
propagation model 2-14, 2-39–2-40
tuning 2-39
pseudo-random noise sequence 5-20
puncturing 2-39–2-40

Q

QoS 2-7
bearer mapping 2-8
classes 2-7–2-8, 2-19–2-20, 2-24
delay insensitive 2-8
delay sensitive 2-8
requirements 2-17–2-18
types 2-7
Quality of Service. See QoS

R

R99 3-2
RAC 2-52
RACH 2-51
radio channel model 2-34
RAKE receiver 2-27, 2-29, 2-38, 2-42
rate matching 2-26
rate set 2-9–2-10
multiple 2-9
properties 2-20
received power 2-49
receiver sensitivity 2-5
dependencies 2-5
guaranteed values 2-5
typical values 2-5
region of overlap 5-19
RNC 2-38, 2-42, 2-51, 2-53
area configuration parameters 2-51
location area 2-53
routing area 2-53
routing area 2-2, 2-52–2-53
code 2-52
RRC 2-51
RRC connected mode 2-51
RSCP 2-49

S

SAC 2-52
scrambling code 5-21–5-22
ambiguities in pilot identification 5-20
ambiguity 5-21
assigning to sectors
in scrambling code planning 5-20
pre-defined 5-21
primary 2-32
reserved 5-21
scrambling code planning 5-2, 5-20–5-22
scrambling codes 2-44, 5-20
orthogonal 2-45
selection combining 2-38, 2-42, 5-6
service
definition 2-4
higher bit rate 2-25
types 2-4
service area 2-2, 2-53
code 2-52
service state
idle mode 2-51
RRC connected mode 2-51
signal combining
uplink 2-42
signal demodulation 2-27
signaling radio bearer 2-26
soft handover 2-2, 2-29, 2-34, 2-36–2-43, 5-6, 5-15–5-16
combining 2-42
downlink 2-38
uplink 2-38
gain 2-34, 2-38, 2-41–2-42
uplink 2-38
uplink 2-42–2-43
soft handover gain 2-36
softer handover 2-2, 2-29, 2-34, 2-36–2-37, 2-39–2-43, 5-6, 5-15–5-16
combining 2-42
uplink 2-42
soft-softer handover 2-41
spreading codes 2-32, 5-6
spreading factor 2-20, 2-26, 2-31–2-32, 5-6–5-7
symmetry 2-10, 2-20, 5-7
bearer 2-20
properties 2-9

T

target C/I 5-6, 5-18
terminal
  GSM support 2-21
  losses 2-21
  output power 2-21
  properties 2-21
  WCDMA support 2-21
terminal categories
  combinations 3-11
  EUL 3-11
  HSDPA 3-10
traffic demand 2-4, 2-12, 2-17, 2-19, 2-22–2-23, 2-27, 5-2–5-5, 5-16
  ASE 2-12
  definition 2-12
  input to WCDMA analysis 2-22
  land-use based 2-16
  mix 2-16–2-17, 2-22–2-23, 5-3, 5-16, 5-18
    definition 2-22
    definition of 2-22
    mapping 2-18
    mapping parameters 2-18
    requirements 2-23
  parameters 5-16
traffic density 2-22
  definition of 2-22
  map 2-17, 2-22, 5-11
  packet switched bearer 2-13
  value 2-13
traffic spreading 2-24, 2-26
transfer delay 2-7
TS23.107 2-7
Tx-increase 5-13

U

UMTS 2-7, 3-2
uplink
  ASE requirements 2-20
  baseband processing algorithms 2-26
  baseband signal processing 2-27
  bit rate 2-20
  calculating load 2-32
  capacity 2-38
  channels
    Interactive and Background 2-20
  convergence 5-8
  coverage 2-38, 5-2
  de-spreading 2-27
  initial transmit power 5-6
  interference 2-12
  load 5-2
  loss 2-21
  noise rise 2-12, 5-8, 5-10
  power 2-20
    settings 5-6
  signal combining 2-42
  symmetry rate 2-20
  UE TX power 5-5
  user activity factor 2-19
  WCDMA analysis
    non-iterative 5-2
  WCDMA quick analysis 5-2
user activity factor 2-10, 2-19
UTRAN 2-3, 2-26, 2-51, 2-53, 5-2, 5-4
  admission and congestion control algorithms 5-4
  cell
    WCDMA RBS explorer 2-30–2-31, 5-18, 5-25
  network 2-18, 2-22
  system 2-18–2-19, 2-22, 5-2
    equipment 2-17
UTRAN registration area 2-52–2-53
UTRAN system 2-18

V

video streaming 2-8

W

WCDMA
  bearer types 2-7
  RBS 2-25
WCDMA analysis 2-16–2-24, 2-29, 2-40, 5-2–5-4, 5-6, 5-9–5-13, 5-16–5-18, 5-20–5-21, 5-23, 5-25
  algorithm 2-4
  algorithms 2-17
    congestion control 2-20
  calculation results parameters 5-16
  chip rate (kcps) 5-15
  convergence criteria 5-12
  convergence limit 5-11
  export statistical traffic data 5-11
  extended region 5-13
  frequency layer selection 5-17

frequency selection 5-17
generating plots 5-18
iterative 2-7, 2-30, 2-36–2-37, 5-2
simulation process 5-2
maximum step size 5-10
modes of operation 5-2
Monte Carlo simulation 5-2
non-iterative 2-35, 2-40, 5-2, 5-18
use of fading margins 2-36
number of connection attempts 5-15
number of iterations 5-10
number of random trials 5-10
options for running 5-3
parameters required 2-17
partial results 5-4
storing 5-12
percent of users converged 5-12
region parameters 5-12
results 5-10
statistics report 2-29, 2-32
traffic demand parameters 5-16
using fixed seed 5-11
WCDMA capacity
planning 2-16
WCDMA coverage 2-16
WCDMA power resources 2-16
WCDMA quick analysis 5-2, 5-8
WCDMA statistics 5-17
WCDMA Transporter 5-12